Smart Meter and Customer Support System

A dissertation submitted for the Degree of Master of Information Technology

A.A.D.A.B Gunawardana

University of Colombo School of Computing

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Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

Student Name: A.A.D.A.B Gunawardana

Registration Number: 2015mit016

Index Number: 15550162

_____

Signature: Date: 24/03/2018

This is to certify that this thesis is based on the work of

Ms. A.A.D.A.B Gunawardana

under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor Name: Dr. Ajantha Athukorala

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Signature: Date:

Abstract

Lanka electricity company is a power distributor which has seven main branches. LECO head office is situated in Colombo 3. Billing processes, disconnection re-connection processes are performed in the main branch. The Main goal of the LECO is quality power distribution for consumers. The smart meter was introduced to LECO in the latter part of year 2016 LECO handles a manual file system for smart meter related transactions which has caused data redundancy and inconsistency. The administration has faced problems while making decisions because of this system. The wastage of the time of the employees due to the inconsistent data is one of the major problems faced. The expansion of the smart meter consumer base, the increasing competition and the need of additional facilities, LECO management have decided to move into an efficient and effective computerized system which will provide speed and timely services.

The proposed system has to include functionalities to support smooth and effective smart meter bill calculation, disconnection reconnection and payment related process. The system should assist system analysis process and a report generation facility. The system will be integrated with the existing billing system of Lanka electricity company.

The system is developed using 'NetBeans' and 'eclipse' with the use of recommended frameworks. Oracle 11g is selected as the database server, a free business graphic application, 'Draw IO' has been used for designing the diagrams. The language used for the implementation of the systems are java, android and PHP languages with procedural language extension to Structured Query Language (PLSQL). The developed system enables connection, service changes, disconnection, reconnection, data analysis, report generation and provide effective communication between the system users. The difficulties of the company employees faced has been successfully addressed by the LECO smart meter and customer support system (SMCS) system.

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List of acronyms

AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
API	Application Programming Interface
DC	Data Concentrator
CSC	Customer Service Center
GSM	Global System for Mobile Communications
LAN	Local Area Network
LECO	Lanka Electricity Company
MIT	Masters in Information Technology
PDF	Portable Document Format
PHP	Hypertext Preprocessor
PLC	Programmable logic controller
RAM	Random Access Memory
RF	Radio Frequency
RUP	Rational Unified Process
SDLC	System Development Life Cycle
SMCSS	Smart Meter and Customer Support System
SMS	Short Message System
SQL	Structured Query Language
UML	Unified Modelling Language
URL	Uniform Resource Locator
WAMP	Windows/ Apache /MySQL /PHP
WAN	Wide Area Network
WWW	World Wide Web
XAMPP	Cross-Platform / Apache /Maria DB / PHP / Perl

Chapter 1:Introduction

Sri Lanka has reached the national electrification ratio of 94%, which is a substantial improvement in the power sector compared with electrification level by end of 2005. The Ministry of power and energy has launched an electricity grid extension program to reach 100% electricity access to entire population, in the country by end of 2012. In order to achieve this target, a separate project for each of the provinces was established with financial assistance from international lending organizations. During the year over two million new electricity supply connections were established with the completion of new rural electrification schemes and extensions.

The transmission projects initiated during this period included construction of new 220kV lines, 132 kV lines and 132 Sub-Stations and rehabilitation of Sub-Stations [15]. Special emphasis was given to improve the reliability of transmission network of Northern and Eastern Provinces. In order to improve the reliability and to maintain a quality of electricity supply in the distribution network, new projects were initiated. Special emphasis was given to reduce the system losses. The overall system losses were reduced to considerable amount by the projects implemented.

The Ministry has placed major priority on electricity demand management and efficient use of energy. The National Energy Management Plan was introduced for Sri Lanka covering a period of 5 years. The proposed projects include consumer awareness programs, regulation on appointment of energy manager and energy consumption reporting for large industrial consumers, minimum energy standards and energy labeling for commonly use appliances were introduced. Electric Energy is a vital resource in everyday life and a backbone to the industry. Being limited its proper use and measurement is very important. Restructuring of power system, penetration of distributed generation and power theft are going to be the key challenges in the near future. The operational information will be crucial for the functioning of the power distribution networks. Integration of smart meter into electricity grid needs implementation of a variety of techniques, controls and software, depending on the required features. The project discusses the functionality of smart meters, the working, benefits and challenges in implementing.

1.1 Problem Domain

LECO has introduced a new Smart meter and consumer support system in order to address the below highlighted outcomes proposed for the next decade. Smart metering promises many benefits and projects in Europe, the United States of America and other countries show that smart metering is technically feasible. Main issues are the actual value of the benefits, the cost involved and the distribution of cost and benefits of smart metering between markets parties involved. Smart metering generally involves the installation of an intelligent meter at residential customers and the regular reading, processing and feedback of consumption data to the customer.

The main expectation of this project is to set up a mean of connecting smart meter with the existing billing system and provide facilities to consumers which have been requested to be implemented by Public Utilities Commission of Sri Lanka (PUCSL).
A smart meter is an electronic device that records consumption of electric energy in intervals and communicates that information at least daily back to the utility for monitoring and billing. Smart meters enable two-way communication between the meter and the central system
LECO's requirement is to have a mean of communicating with the meters. Therefore a centralized system should be implemented in order to capture transactions and send actions.

In the area of improved customer service, Smart Metering will deliver the following advantages

- Eliminate estimated readings.
- Bill generates to the actual consumption in the billing period.
- The Smart Meter will report back electricity issues (such as periods of low voltage) to deliver better quality of supply.
- Facilitates pre-payment schemes.
- The system enables new capabilities to consumers for a better management of their own electricity costs
- Electricity suppliers can offer new pricing options to allow them pass onto consumers a price which better reflects the actual cost of generating the electricity in a given period. (Peak or off-peak, day or night).

- It provides consumers with precise details of their consumption patterns, allowing them better manage their consumption.
- Facilitate the use of home energy management systems.
- Enable ways in which consumers can manage their electrical use remotely.

1.2 Motivation

The new concept of smart meter and software solution is to create an interface within a smart device, Lanka Electricity Company(LECO) users and consumers is an exceptional experience. The deployment of a smart meter system begins with selection of the technology and the planning for installing, operating and maintaining. Utilities have integrated within the deployment process many elements of management, control and compliance to support successful project implementation. Communications with utility customers concerning the utility's smart meter project begins before the deployment of meters begin. These communications should inform the customer about the new smart meter system, the benefits, and the way system will affect the energy delivery and billing. Over and above it is important to address concerns or issues that may have been raised earlier locally or in other jurisdictions. The communications can be in the form of news releases, mailings or bill stuffers. Technology rapidly develops and it is enthusiastic to work with new equipment. World is moving toward fully automation process, in Sri Lanka revenue officers face problems due to the outdated walking from home to home method. Reaching toward the ordinary meter has become a problem as houses are evacuated during day time. Smart meter will be the best solution for above mentioned problems.

Customer satisfaction begins with customer communication and education. Customer support system are getting popular among consumers as people live busy lives and they have no time to visit the customer service centers to inquiry of the details they need. In order to satisfy the need of support services, customers support module will encourage consumers to solve their problematic areas by themselves. This project is an interesting opportunity to apply the knowledge gained through the MIT program and a great experience to apply the knowledge gained over the years in a practical manner. Experiencing new technology while developing a system will be a great opportunity.

1.3 Objective of the project

The smart meter is an advanced energy meter that obtains information from the end users' load devices and measures the energy consumption of the consumers and then provides added information to the utility company and/or system operator. The main objective of the project is to develop a mean to communicate the LECO billing system with the remote meters. Smart meter systems are varied in technology and design but operate through a simple overall process. The smart meters collect data locally and transmit via a Local Area Network (LAN) or data connection modem to a data collector. This transmission can occur as often as 15 minutes or as infrequently as daily according to the use of the data.

The overall functionalities of the proposed system are listed below and the objectives of the project highlighting into major three areas.

1. Application to connect the LECO billing system and the smart meter

System integration is a prominent topic these days due to the increasing advances in building automation technology. System integration allows facilities managers to work from a single work station. When integration is done properly, real-time alerts will be sent via work orders or alarm systems. Many software companies now offer mobile capabilities, so management can get alerts through their mobile phone or other device. Integration can include multiple branches on multiple sites, and is not limited to one individual branch.

Problems can be solved and changes can be made with a few clicks rather than visiting multiple computer systems. It simplifies the process and makes it easy to manage. The communication between the existing billing system and the smart meters has to be maintained. The transactions and actions performed in the system have to send to the selected meter immediately. The readings of the meters have to feed to the billing system with 15 minutes' intervals. Disconnections re-connections has to be captured from billing system and the connection status of the relevant account has to be updated immediately.

2. Facilitate the consumer to view, manage and control the consumption and enjoy other services online.

consumers would be willing to pay more money for a superior experience. Price and product are no longer the top differentiators for a brand, experiences are. The customer experience becomes more crucial, it's no surprise that forging emotional connections with customers has grown more important as well. Good service solves the customer's current problem and creates a positive emotional connection; great service goes a step further by heading off future issues. Provide a consumer a mean to inquire the account details, perform payments, analyze previous consumptions, calculate current bill and analysis the consumption with the appliances use in day to day life. Making better customer experience without visiting service centers is one of the main objectives of the system. Consumers can predict their own bill, examine the current usage will lead to save energy intentionally.

3. Facilitate the employees of the company to manage, analyses the transactions.

Provide a platform for LECO employees to meter provisioning, decommissioning, mode changes, analyses data, find faulty accounts, analyses periodic data and generate monthly reports. Creation of the smart meter account, activating allocating smart meters to consumers are facilitated in the system. The higher management has the ability to examine the abnormal consumptions, load profile flows. LECO users from test labs, branch users will facilitate with the day today transactions that perform manually will be replaced with the system. Each user will get their own login and the system will track the transactions done by the users. Capturing readings generated form the smart meters, calculate bills will be automated with the system. The time consuming processes have automated and expected to reduce the employees unnecessarily allocated to processes. An organization’s technology demands grow; productivity becomes a bigger concern. Typically, as other business areas were given tools to increase their productivity and effectiveness. Make more efficient services by enrolling employees in other priority duties, processes that can be automated, scheduled and time consume when done manually. The reliability of workflow automation ensures that processes essential for corporate governance are executed 100% of the time in accordance with legislation. Making the process reliable is an objective of the system. Manual tasks, given that they are performed one-at-a-time and at a slower rate than an automated task, will cost more. Automation plays a major role in order to accomplish more by utilizing fewer resources.

1.4 Scope of the project

The proposed system is acting as a centralized system which provides a mean of combining several systems. LECO billing system does number of transactions daily. The transactions which affect the meter should be implemented immediately. The transactions generated from the billing system should send to the centralized controller with fifteen minute intervals. Smart meters functionalities are different from ordinary meters' functionalities. The readings of the consumption of consumers will not be read by revenue offices. Readings has to be collected in a centralized server in order to do bill calculations. Payments done to the smart meters has capture immediately and direct the account for the relevant processes. The existing consumers of LECO will request for smart meters' connections. The conversation has to be facilitated in the proposed system. Smart meter consumer's reconnection and disconnection processes differ from the ordinary consumer's process. There for the proposed system has to facilitate the new procedure of disconnection and reconnection. Smart meter consumer's bill analysis, consumption analysis has to be included in the system as the top level manager's main focus is to analysis the new implementation.

Daily monthly and annual reports need to be generated in the system. All the reports should be able to take branch wise. The system functions should be able to be predicated using the proposed system. Consumer will be facilitated with bill calculation prediction under the prediction module. System facilitate the employees of the company to manage maintain the resources of the system. Maintenance facility should be available for the technicians in the test lab in Lanka electricity company. The maintenance module has two major areas as follows:

- Meter provisioning

  Meters will release from the test lab to the customer service centers. The meters will allocate to accounts and the details of the meters' insert to the system.

- Meter decommissioning

  Remove defected meters from the centralized controller.

Customer support system will consist of two main application types.

- Mobile Application - Mobile application is developed for android user and will be available in play store.

- Web Application - Web application for consumers will be published. The consumers who have registered can enjoy the facilities given in the web application. The registration is available in the application itself.

The purpose of customer support system is to enable to manage, organize and track customer requests using a single platform. Customer service management is the combination of solutions, workflow and processes that go into managing the customer relationship. The consumers should be able to examine account details, request for services, analyze the accounts status using the system. Customer and company interaction will be maintained using the system.

1.5 Structure of the thesis

Structure of thesis chapters is illustrated below with a brief description of each chapter. Each chapter relates to a phase of software development process and includes some information and work carried out in that phase when developing the proposed system.

Chapter 1 - Introduction
The introduction chapter provides the overview of the work in a manner that motivates the reader.

Chapter 2 - Background
A concise summary of the background information to the implementation shall be presented in this chapter.

Chapter 3 - Analysis
This chapter contains descriptions of current problems, goals of the project and their limitations are discussed here. Methods used to gather requirements and a detail description of functional and non-functional requirements including the top level use case diagram are included. A brief description of studied similar systems is also included. It is important to note that the analysis chapter forms the foundation on which you can draw your conclusion, identify patterns and provide recommendations. The basic utility of the dissertation research work relies largely on how well the analysis has been conducted.

Chapter 4 – Design

Design phase of the development process is discussed in this chapter. System development life cycle, proposed system architecture and design approach are discussed by considering alternatives and provides justifications for selections. This investigation was concerned generally to see how new technologies come into the everyday lives of different people, and how in turn these people engage with these offerings: the way they are appropriated, including adoption, learning and struggling, but also other strategies for non-adoption, or arm's length appropriation

Chapter 5 – Implementation

The chapter discusses the implementation of the system. The details of implementation environment of the system, outlines the development tools used during the development, an overview of the completed development process. The Implementation section is similar to the Specification and Design section in that it describes the system but it does so at a finer level of detail, down to the code level. The section describes any problems that may have arisen during implementation.

Chapter 6 - User Evaluation and Testing

Software Testing is the process of executing a program or system with the intent of finding errors or it involves any activity aimed at evaluating an attribute or capability of a program or system and determining that it meets its required results.

Chapter 7 - Conclusion and Future Work

This Chapter included conclusion, challenges faced and lessons learned along with the future work of the implemented project.

Chapter 2: Background

The intelligence of the meter is incorporated in the electricity meter. Smart meter has three basic functions, measure the electricity generated, remotely switch the customer off and remotely control the maximum electricity consumption. The electricity meter communicates by means of a modem. An important characteristic is the communication infrastructure used by the smart meter for the communication. The wireless modem communicates with the server using Global System for Mobile Communications (GSM) or General Packet Radio Service (GPRS). A smart meter is logical successor of the mechanical electricity meter. Smart Metering is often referred to as automated meter reading (AMR), or in the case of real-time, two-way communications, as advanced metering infrastructure (AMI).

Figure - 1 below demonstrate the connectivity options of a smart meter over a typical meter.

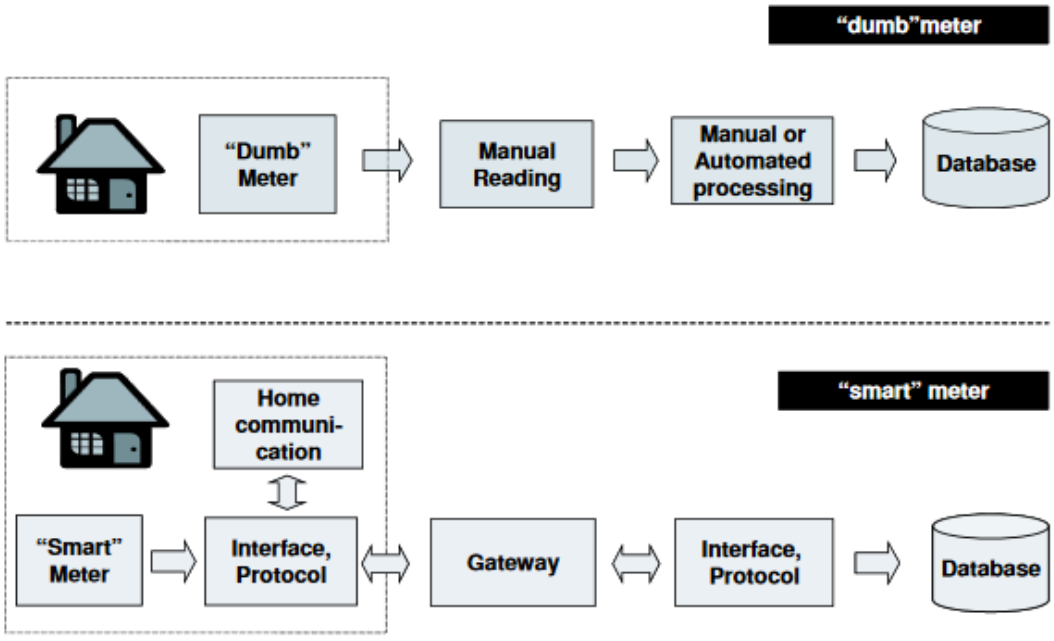


Figure 1 - Connectivity Options

Immediately upon smart meters' installation, LECO requires another type of operation for data collection and data communication. The smart meters introduce a high amount of frequent data flows, processes and systems must be adapted and prepared accordingly. The data collection process will not depend on clients being at home but will be a continuous, automated process, which should simplify daily operation of the metering company. Application programmed interface has to implement between meters and the proposed system. Gathering all data, the grid operator will be able to predict electricity flows more accurately and use this knowledge in network and maintenance planning. The automation of the data collection process, with more, recent data on a higher frequency, will put higher requirements on systems. This have an impact on market facilitating processes, as reconciliation of formerly profiled users may become unnecessary.

The smart meter offers possibilities to offer new and dedicated services to their customers. The smart meter may become a gateway into the home of the customer, to provide new value added customer services such as the billing process, real consumption data can be used, simplifying the current process of advances and recalculation. Mobile application and web application proposed to develop should facilitate the above mentioned scenarios. The consumer support should be available consistently. The payments done through the web application should connect with a payment gateway the securities of the transactions need to be addressed as a priority. Introduction of smart metering is a logical step in a world where all communication is digitalized and standardized (Internet, E-mail, SMS) and where cost of 'digital intelligence' are still rapidly decreasing. Moreover, an advanced metering infrastructure offers more than just reading and controlling smart meters. Proposed system dedicated gateway to the customer's home, offering additional energy related services. The system can be used for stimulate the customer to change his energy behaviour and control of household appliances in relation to local generation of electricity. SMS gate way connectivity has to build up during the installation.

Smart Meters are being rolled out nationwide and internationally, can do so much more for consumers because they provide a communication link with the utility. Businesses and homeowners will enjoy a more reliable power system, more accurate billing, and more innovative services as the utility monitors usage more often than in the past, made possible by remote and frequent reading of consumer loads.

2.1 Similar Systems Available

1. **“Ontario Smart” smart meter system and customer support system in Canada.**

Based on the self-developed cloud computing platform, ZTE NICEs solution provides an end-to-end AMI solution that offers functions including meter data collection, statistics analysis, customer relationship management, charging, and ERP. In addition, ZTE NICEs, on the lower layer, provides unified access and management, and on the upper layer, achieves cooperation between industrial chains Rolling out in 2009, local utilities started to install smart meters in every home and small business throughout Ontario Smart meters were a part of a new “Advanced Metering Infrastructure (AMI)” a part of the new electrical system in Ontario, which is anticipated to be completed by 2025. The Ontario Smart Grid Fund was established in 2011 by the Ontario Ministry of Energy to support the growth and advancement of the province’s electricity grid [17]. Earlier this month the provincial government announced a new round of project applications for the fund. The Ministry of Energy said it will consider applications for consumer - focused initiatives that seek to optimize smart technologies and systems by involving customers as active energy sector participants. Self-healing grids that can perform fault location, isolation and service restoration using automated technologies and communication systems is another priority together with enhanced fault prevention that can precisely detect faults while protecting equipment and enabling faster response. The below listed features are included in the “Ontario Smart” system.

- Smart meters instantly track outages, meaning faster service response and shorter outages overall.
- Customers will be able to view their power usage hour-by-hour, get a forecast of their next bill, and set alerts so they can adjust their activity to reduce both their carbon footprint and bill.
- Businesses can get more detailed usage reporting which will help them cut costs and make investments in items that help their business grow.

- The grid work more efficiently with, and will help better integrate, renewable power sources [13].

2. ‘YItran’ smart meter system by BC Hydro China.

The YItran modular smart meter system employs a highly adaptable, platform for advanced metering infrastructure (AMI) designed to advance the transformation of the energy industry [12]. Yitran's meter project allow utility companies to utilize Energy Management/Smart Grid and other environmentally efficient solutions, benefitting the consumer as well as the provider. Utilities can respond as needed by making necessary alterations to prevent blackouts, engage in emergency load shedding, detect and prevent meter tampering, etc. The result is a more efficient use of utility resource electricity.

Consumers are able to benefit from system where a concentrator is placed near the neighborhood transformer to collect data from electricity meters located in houses connected to this transformer. Such a system can also be used for value added services such as energy/thermostat management and flexible tariffs. “Smart Appliances” networked to each other and to the Internet, can be monitored and controlled locally from a single or multiple locations within the house, or remotely via the Internet. Home owners can control their lights, security and appliances as well as receive real-time reports and alerts. YItran system provides the below mentioned functionalities.

- Automated Meter Reading (AMR)
- Advanced Meter Management (AMM)
- Demand Response & Real-Time pricing
- Home & Building Automation
- Appliance Control & Diagnostics
- Security and Access Control
- Environmental Control
- Street Light Control
- Vending Machine Control
- Signage Control

This new generation of smart meters is designed to meet the significantly broader set of advanced metering, communication, control, transferring data and smart grid requirements that many utilities are facing today and that will continue to develop in the years to come.

2.2 Challenges and limitations of the similar systems.

The APIs developed for transaction capturing in RF & PLC Solutions Partner smart meter system was developed using Java language. The scripts were held in a server and were called using a java windows base graphical user interface. The major challenge RF & PLC Solutions Partner smart meter system has faced was to keep connectivity consistency between centralized system and the sub systems as java based APIs where getting corrupted because of large volume of data. The number of transactions is massive as this was implemented in china a country with high population. RF & PLC Solutions Partner smart meter system have spent more than twenty million to change the scripts and the technologies for web in order to resolve the issue. In order to overcome the limitations addressed above APIs can be developed on PHP based platforms. PHP based platforms hosted on XAMPP server supports large volume of transactions better than java based methods.

Canadian government focuses on the security and privacy aspects of the smart metering systems. Potential attackers, security threats and attacks on smart metering systems are listed and the security approaches to address the security issues are presented. A security by design approach for secure smart metering is discussed in the paper. The major results of a security by design approach for smart metering systems developed in the project. There were five attackers done to the payment system within the first week of implementation. Canadian government came up with a technology to detect the IP addresses of the payment authentication holders which has a high accuracy and reliability. The invented solution is reasonably one of the best solutions and it consumes more costs. A developing country like Sri Lanka it will be beneficial to focus on an options which are more cost effective. The token based system may enhance the security in a cost effective way. Token based web API authentication is cost effective and addresses the requirement of a medium sized companies. Benefits expected to gain from the token based web API authentication system is as follows:

- The token based systems are stateless and scalable
- enhance security and support extensibility
- supports for multiple platforms and domains
- it is standard based.

2.3 Technology Options

Table -1 demonstrate the selected technologies for the project.

Module	Technologies selected
Smart metering system	Java , oracle 11g
Customer support module	Oracle 11g, PHP , Android , JSON Tokens, Laravel

Table 1 - Technologies selected

The requirement for the proposed system is to develop a windows base application for LECO user and web, mobile application for customer support system. Selecting java as the programming language over other languages are explained below.

Performance - Generics improve compiler-assisted checking of types largely by removing casts from source code. Java, generics are implemented using erasures. Generic type parameters are erased and casts are added upon compilation into byte code. C# takes generics even further by integrating it into the CLI and allowing type information to be available at runtime, yielding a slight performance gain. [10]

- **Exception handling** - Java distinguishes between two types of exceptions checked and unchecked. Languages such as C# chose a more minimalist approach by only having one type of exception. The ability to catch exceptions can be useful, the language can have an adverse effect on scalability and version control. Exception handling is one of the main advantage.

- **Polymorphism** - Polymorphism is the ability of an object to take on many forms. Java enables polymorphism by default. The same method can be called with different permanents in order to get the expected output.

- **Enumeration** - Java takes the enumerations further by treating it as a named instance of a type, making it easier to add custom behavior to individual enumerations. Enumeration is a list of named constant. In Java enumeration defines as a class type. Enumeration can have constructors, methods and instance variables.

Selecting PHP as the programming language over other languages are explained below

1. **Fast Load Time** – PHP results in faster site loading speeds. PHP codes runs much faster than ASP because it runs in its own memory space while ASP uses an overhead server and a COM based architecture. PHP supports faster frameworks than other languages.

2. **Less Expensive Software** – Working with PHP, most tools associated with the program are open source software, there for cost on development can be reduced.

   Less Expensive Hosting – ASP programs need to run on Windows servers with IIS installed. PHP only require running on a Linux server, which is available through a hosting provider at no additional cost. cost effectiveness was taken into consideration.

3. **Database Flexibility** – PHP is flexible for database connectivity. It can connect to several databases the most commonly used is the MySQL database. The flexibility of a database is essential.

4. **Increased Available Programming Talent** – PHP is used more often creating a larger pool of talent to choose from for modifications and building and lowering the cost per hour for those services. Selecting Android for mobile application is as follows:
   1. **Portability** - Native Android apps are developed using the Java programming language, and can easily be ported to other mobile operating systems like Blackberry, IOS, Symbian and Ubuntu. Portability is an essential feature.

   2. **Supports java** – Android supports java and integration between the windows base application and the mobile application is possible.

   3. **Low barrier for entry** –Android app development can be done on Windows, Mac and Linux. Apple App Store requires a yearly fee of $99, whereas to register as a developer on the Google Play Store requires a onetime payment of $25.

Table 2 below demonstrates the summarized view of the Language selection nominees. The weightages clarify the most suitable languages for the development. There are plenty of technical characteristics with which to compare programming languages when selecting a language considerations should be how many key words, maximum length of identifier, type-checking facilities, polymorphism, overriding.

	Java	**C#**	**PHP**	**. Net**	**IOS**	**Android**
Performance	5	4	5	4	5	5
Exception handling	5	5	4	5	4	5
Polymorphism	5	4	4	4	4	5
Enumeration	5	3	4	4	5	5
Fast Load Time	5	5	5	4	5	5
Less Expensive Software	5	4	5	3	2	5
Less Expensive Hosting/ implementation	5	3	5	3	3	5
Database Flexibility	5	4	5	4	3	5
Increased Available Programming Talent	5	4	5	4	5	5
Total	**45**	36	**42**	35	36	**45**
5- Excellent, 4- Good, 3- Average,2-Fair, 1- Poor						

Table 2 - Summarization of Language Selection

When selecting a language like java and Android the develop can gain the following benefits. Ease of learning

- Ease of understanding
- Speed of development
- Help with enforcement of correct code
- Performance of compiled code
- Supported platform environments
- Portability
- Fit-for-purpose

The API model has been used frequently in applications. The concept has come about as applications cannot just rely on their own data, for a project to fully gain its potential, system must be able to have third-party applications, intermingle with other applications, and have its data easily accessible by developers.

Selecting token based system over other method is described below.

- **Stateless and scalable**
  Tokens are completely stateless, and ready to be scaled.
- **Provide security**
  The token expires after a set amount of time; the user will be required to login once again. This helps to stay secure. There is also the concept of token revocation that allows us to invalidate a specific token and even a group of tokens based on the same authorization grant.

- **Extensibility**
  Tokens will allow to build applications that share permissions with another.

- **Supports multiple platforms and domains.**
  Tokens provide selective permissions to third-party applications. Token based supports multiple platforms and domains.

- **Standards based**
  The standard proposed to use for the implementation is JSON Web Tokens. JSON Web Tokens has a great amount of support across a variety of languages.

Chapter 3: Analysis

3.1 Introduction

The analysis stage is one of the main stages used to retrieve useful information from a collection of data. The process of analyzing can be defined as a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information [5].

3.2 Feasibility study

Feasibility study can be defined as a short focused study which claims the feasibility of the project considering resources, cost benefits, technology available. The study decides whether the proposed system will be worth to develop.

The feasibility study further considers the below mentioned facts

- The contribution of the proposed system on the objectives of the organization.
- Availability of the technology for the system development.
- Ability to integrate the system with the other exiting systems.

Fact gathering

The analysis phase will ensure that all the problems and requirements are identified clearly. The main functional and non-functional requirements identified and were discussed with the customer and the unclear areas were sorted out by observing and questioners.

- Interview - A face to face discussion and interview took place with the client and understood the main processes of the company and the difficulties that can occur while implementing the system.
- Questionnaires - A prepared set of questions were distributed among the consumers and understood main non-functional requirements the consumers expect. Questioner is attached in the Appendix C section
- Observation - The manual system was observed carefully for several days and discovered the difficulties the employees face. The manual system is time consuming and heavily based on paper work. The majority of the employees have capability of using the computers and they are willing to be work in a computerized system.

3.3 Model the existing system

LECO has an existing system to support billing processes, connection related transactions, payment and disconnection processes is manual and consist of a huge amount of paper based work. Report generation is done manually, the reading gathering process of the individual consumer is done manually, Account creation and service changes handled manually and recorded in books. The figure 2 shows the functions done in the manual system.

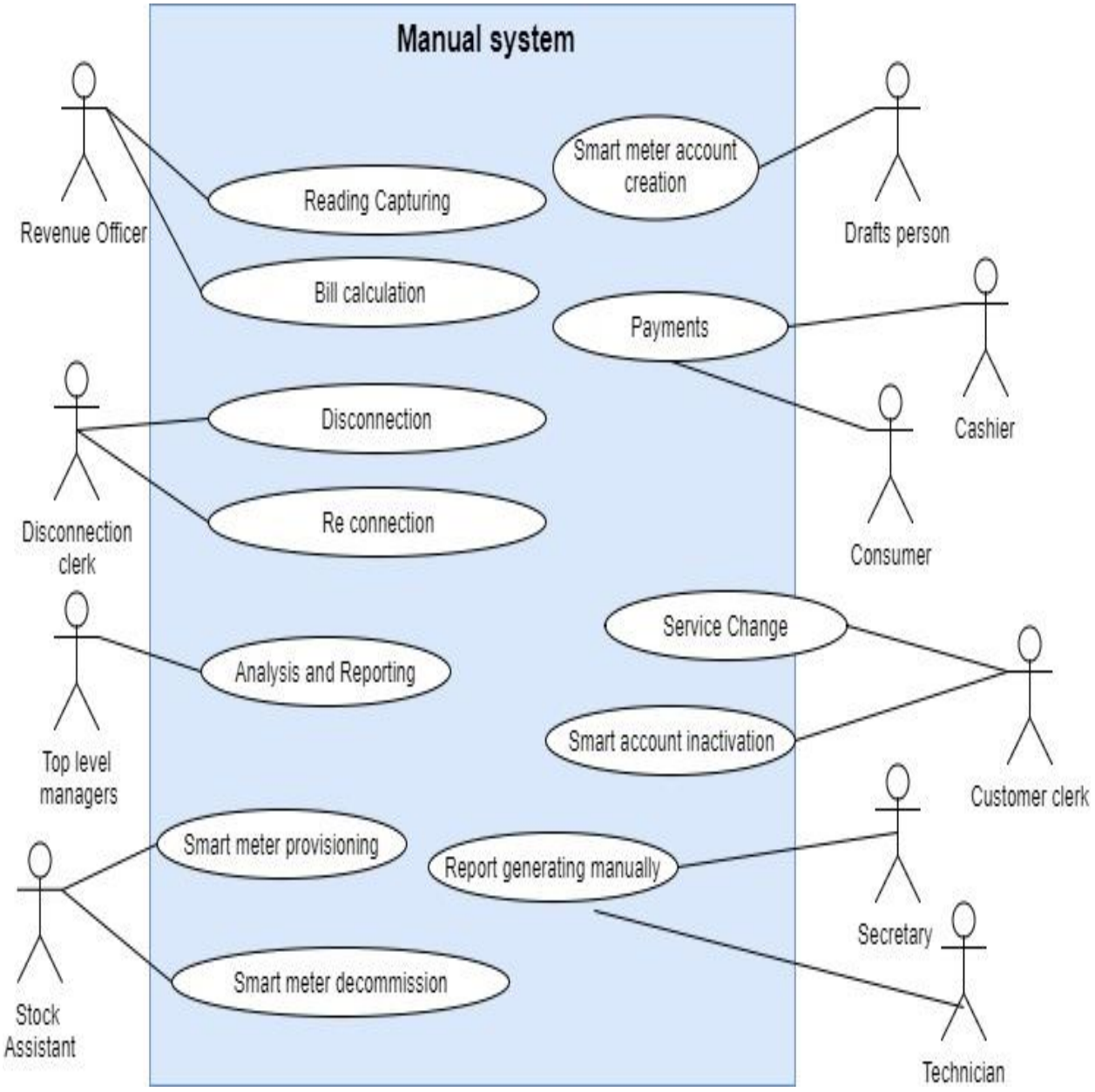


Figure 2 - Existing Manual system

The problems of the above mentioned manual system can be listed as follows:

- Customer details are inaccurate and insecure.
- Heavily based on paper work.
- Analyzing data will be time consuming.
- Customers need to visit the branches in order to get basic details of the system.
- Customers are not facilitated to do payments online.
- Transactions are time consuming and complex.
- Report generation is complex.

In the latter part of the facts gathering most of the functional and non-functional requirements were identified. The fact gathering task solved most of the complicated areas of the system and identification of the system users were done during this phase. The system users, the transaction types and frequency of the actions occur details can be listed as given in the table 3.

User name	Role	Frequency of usage
Manager	Data preview and analysis/ report generation	Regular
Chief clerk	Data entry/ Data preview	Regular
Administrator	Data entry/ Data preview/ user handling	Irregular
Customer clerk	Data entry	Regular
Draft Person	Data entry	Regular
Disconnection clerk	Data entry/ Data preview and analysis	Regular
Consumer	Data entry/ Data preview	Regular
Technician	Data entry / Data Preview/ Report generation	Regular

Table 3 - Users Identified for the proposed system

3.4 Functional Requirements.

LECO has seven branches and twenty-three customer service centers. The employees from the above mentioned branches will involve in the processes of the proposed system. There for access control mechanism need to be implemented in the system as well. The high level perspective of the smart meter and customer support system is demonstrated in figure -3.

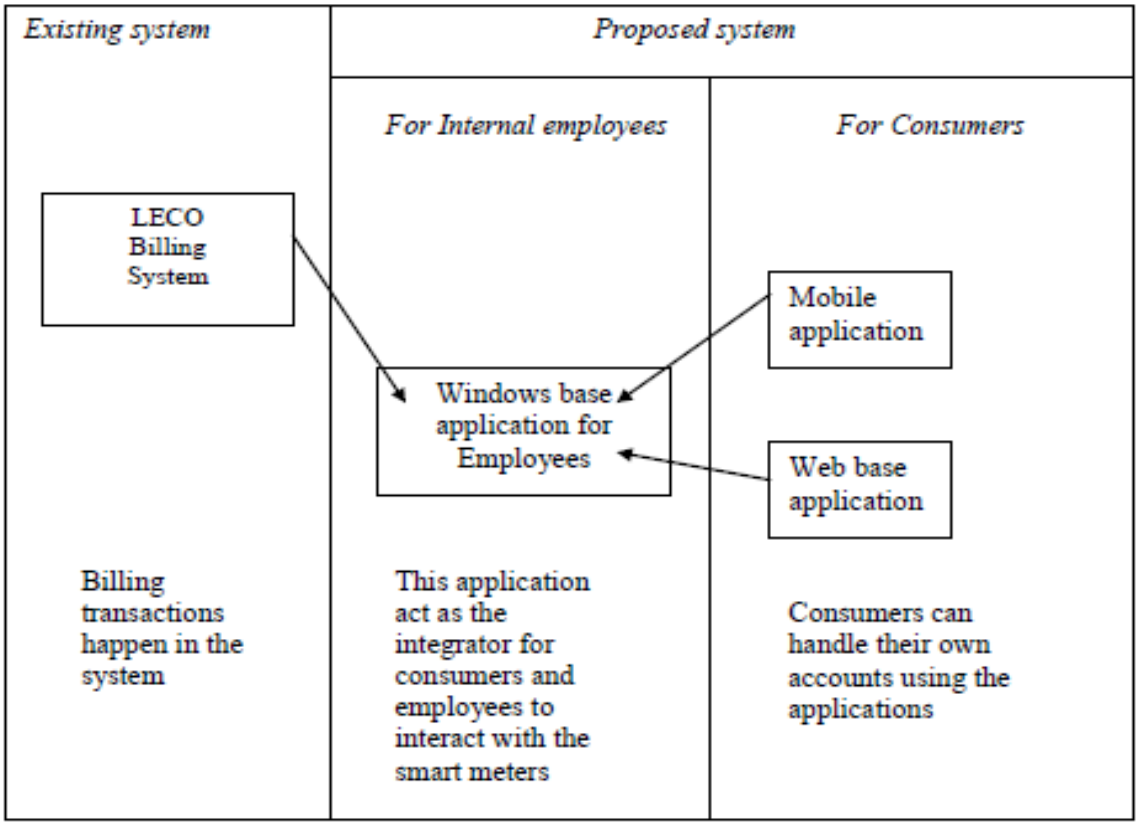


Figure 3 – High level perspective

Based on the functionalities the system is divided into main modules, each module is handled by different users and modules are interconnected with each other to provide a consistence communication. Table 4 demonstrate the module overview. The functional requirements were confirmed and new functionalities to support employees were added to the system.

Module Id	Module Name	Description
1	Authentication	Access controlling and user login handle under this module
2	Connection	New account creation for the smart meter account holder is facilitated in the Connection module.
3	Disconnection/Reconnection	Smart meter consumer disconnection and reconnection processes will be automated in the module.
4	Payments	Payments done for bills, disconnections are handled in the given module.
5	Service changes	Conversion of normal consumers to smart meter consumer is handled in the module.
6	Maintenance	Smart meter maintenance is handled in the maintenance module
7	Smart meter billing	Reading capturing and automated bill calculation will be implemented in the module.
8	Analyzing	Data analysis is enhanced under this module.
9	Perditions	Predications for managerial users are provided in the system.
10	Maintenance	Smart meter maintenance is handled in this module.
11	Reporting	Reports for top-level manages are handles in the module.
12	Customer Support	This module consists of two major areas as mobile application and web application.

Table 4 - Module breakdown of the system.

The overall functionalities are demonstrated in the figure - 4. The figure shows how the smart meter connects with the existing billing system. Customer web portal and mobile application supports the customer interaction with Lanka electricity company. The centralized controller acts as the interface between LECO and smart meter. Billing system and smart meter application connectivity is enhanced with the use of centralized system.

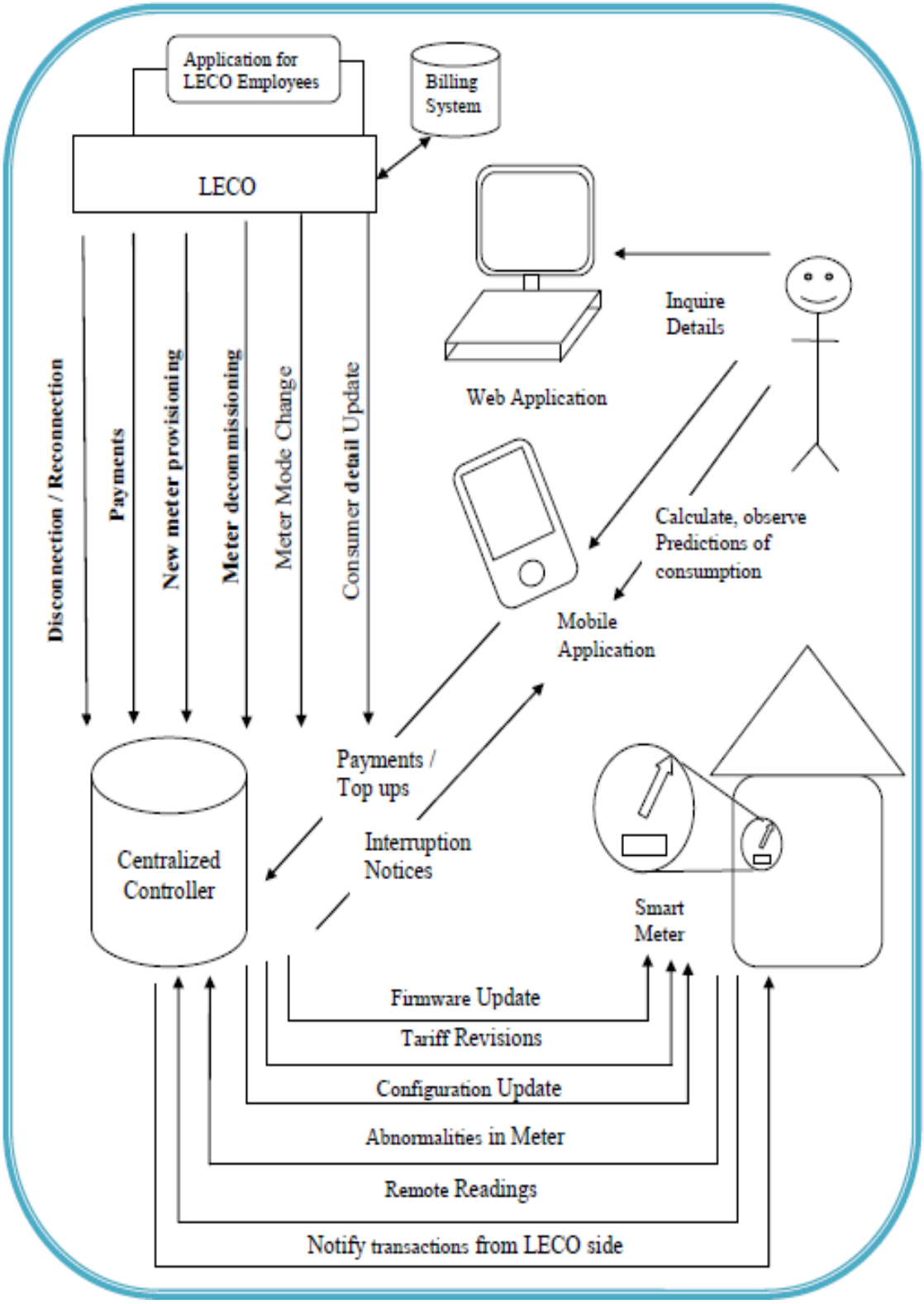


Figure 4 - Overall functionality

3.4.1 Authentication Module

User has to login to the system using their own usernames and passwords. Every user will be awarded the Inquiry facilities apart from the above mentioned module the privileges offering by the system will differ from user to user. The administration of the system has privileges to add users to the system.

3.4.2 Connection

Connection module consist of process of account creation and activation process. An account goes through three statuses during this module. Main three statues are described in the below figure 5. Proposed system has to facilitate the requirement of three stages.

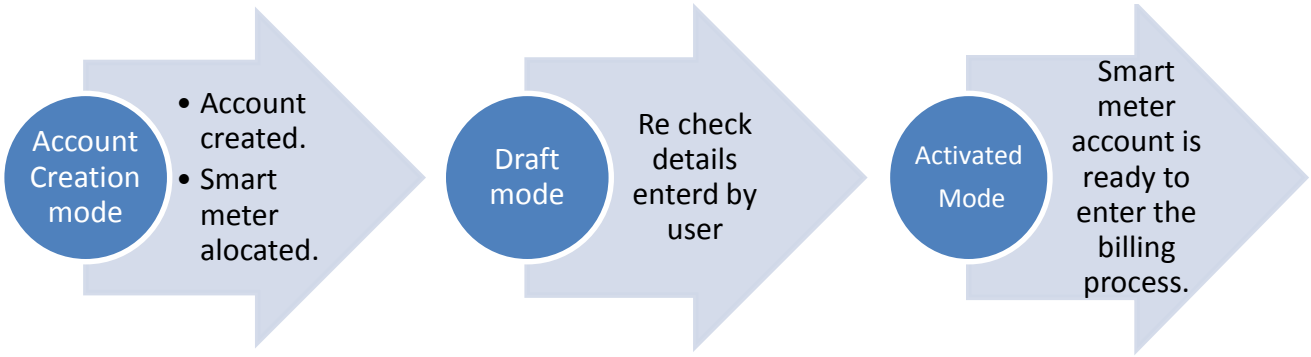


Figure 5 - Account Modes

3.4.3 Disconnection / Reconnection module

- Disconnection – Disconnections done due to non-payment, safety reasons and unauthorized connection. Disconnection should notify to the meter immediately.
- Reconnection – Disconnected consumers go through a reconnecting process once LECO receives a payment of requested amount. Reconnection should notify to the meter immediately.

3.4.4 Payments.

Payments for Smart meter accounts can be done online, via branch cashier or to LECO registered collection point (E.g. Super markets, Banks etc.). The Payments done by the smart

meter consumers should be notify to the meter side immediately. Figure - 6 indicates the overall functionality of the payment process.

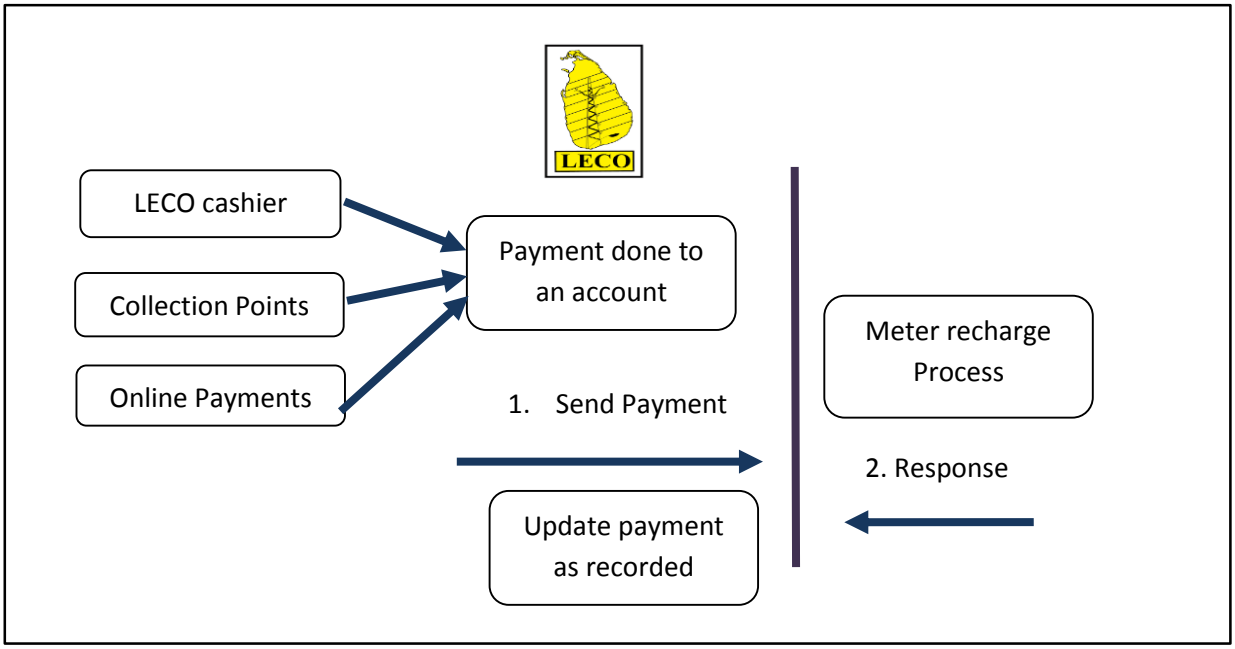


Figure 6 - Payment Process

Under the payment module the main functional requirements are as follows:

1. Develop Application Programming interface to capture online payments.
2. Immediate notify the recharge to smart meter.
3. Settle generated notices and orders generated in the reconnection module.
4. Send payment amount to the smart meter as a wallet updating.
5. Once the payment is made the consumer will get an SMS from Lanka electricity company.
6. Registered consumers can check the account balance by sending an SMS.

3.4.5 Smart meter billing

Remote bill calculation will perform only to the smart meter consumers

- The reading data that generates from the meters will feed to the billing system every fifteen-minute interval.
- The running bill value will calculate using the data.

During this process, with the condition that bill value has exceeded the given value a SMS will generate to the consumer.

3.4.6 Service changes

The transactions which need to consider in the process listed below

- Meter change - Change the meter of the consumer due to a meter defect.
- Tariff change - Consumer change the tax or duty to be paid on a particular class of imports or exports.
- Configuration changes - Change the data retrieval intervals, data packet formats of the meter.
- Connection close – Remove temporary connection holder's meter

The smart meter has several modes depending on the purpose. The figure -7 shows the status and the modes of the meter. The system should provide opportunity to support the changes in modes and status.

- Post-paid to Pre-paid
- Prepaid to post-paid
- Normal consumer to smart meter consumer

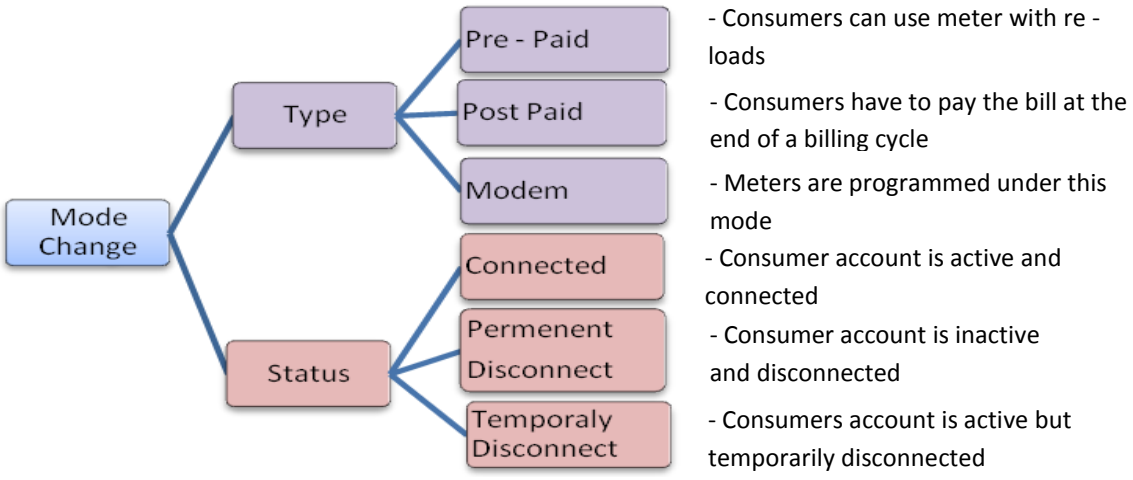


Figure 7 - Meter Modes

3.4.7 Maintenance

Meter provisioning

Meters will have released from the test lab to the customer service centers. The meters will allocate to accounts and the details of the meter's insert to the system. The system should facilitate smart meter provisioning using text file upload. Only Provisioned meters should be able to allocated for the meters.

Meter decommissioning

Remove defected meters from the centralized controller using text file uploader.

3.4.8 Customer Support Module

Facilitate the consumer to view, manage and control the consumption and enjoy other services online. Application developed for the consumers to view, manage and control the consumption and enjoy other services online.

- Consumer registration- Facility for consumers to register with the LECO customer support portal.
- Check the current outstanding bills – Inquire outstanding bills.
- Check the previous bills – View previous bill values, details.
- Check the current consumption – Check running bill value which changes every fifteen minutes a time.
- Account balance – Inquire current account balance
- Pay bills online – Payments facility for consumers a SMS will generate to pre - paid consumers.
- View payment history – View Payment done by the consumer
- Ownership changes done to the account
- Meter changes/service changes done to the account
- Handle multiple accounts at belongs to one owner - One owner can own many accounts. Using one login the consumer can handle all the accounts he/she owns.

Calculate and control the power consumption from home – Consumer can pick the equipment which they use. The application will calculate consumption for selected equipment. Consumers can see the direct impact your habits and lifestyle have on the bill. The option is particularly useful to Pre-paid meter customers, who can better track how their usage impacts their available credit by making energy usage easier to understand, make smarter decisions to save energy and money.

3.4.9 Reporting/ analyzing and Predictions

Daily monthly and annual reports need to be generated in the system. All the reports should be able to take branch wise. Few of the reports are mentioned below.

- Meters provisioned
- Abnormal consumption
- Meters not activated
- View and analysis the readings
- PUCSL reports
- Abnormal transformer generation

3.5 Non-functional requirements

Non-functional requirements are not directly concerned with the specific function delivered by the system and these are constraints on services or functions offered by the system. The non-functional requirements discovered by observing and interviewing. There is an important attribute of non-functional requirements that does differentiates them from other requirements and that is they are optional: Not all solutions will need to specify all categories of non-functional requirement. On the other hand, all solutions will need a specification of their functional, data and process requirements. Requirements need to be well thought out, balanced and clearly understood by all involved, most importance is that requirements are not dropped or compromised halfway through the project. Non-functional requirements cover all the requirements which are not covered by the functional requirements. They specify criteria that judge the operation of a system, rather than specific behaviors. Additionally, non-functional requirements help you to measure the quality of the function. A non-functional requirement states the way a functional requirement behave on top on the function.

Usability and easy navigation

Proper error messages should give by the system while minimizing the occurrences that user can make errors. The system should be designed in a way to enable easy navigation through the system by using easy to use menus and icons. The interfaces should consist of the following features:

- Clear - Clarity is the most important element of user interface design. Indeed, the whole purpose of user interface design is to enable people to interact with your system by communicating meaning and function.
- Concise - maintain consistency throughout the entire system. The colour schema and formats has to be consistent throughout the system.
- Familiar - Identify things that are familiar to your users and integrate them into your user interface.
- Responsive - The interface provides form of feedback to users.
- Consistent - Consistent interfaces allow users to develop usage patterns. the feature is essential and helps to extrapolating from those previous experiences.
- Attractive - Attractive in a sense that it makes the use of that interface enjoyable.
- Efficient – System should allow user to perform the functions faster and with less effort.
- Forgiving – Users make mistakes, system should prevent users from costly mistakes. The system should have the ability to roll back.

Reliability

Software Reliability is the probability of failure-free software operation for a specified period of time in a specified environment. Software Reliability is an important factor affecting system validity. Reliability differs from hardware reliability in that it reflects the design perfection, rather than manufacturing perfection. The high complexity of software is the major contributing factor of Software Reliability problems. Software Reliability is not a function of time. The modeling technique for software reliability is reaching its prosperity. Measurement in software is in its infancy. Various approaches can be used to improve the reliability of software, however, it is hard to balance development time and budget with software reliability. Information presented by the system should be accurate and up to date. System should ensure integrity of data when performing some functions such as entering, updating and deleting and searching [18].

Security

System should provide secure login facility to its users. Software security is the idea of engineering software so that it continues to function correctly under malicious attack. Software security best practices leverage good software engineering practice and involve thinking about security early in the software development lifecycle, knowing and understanding common threats. The system is implemented with a token based authenticated system.

Maintainability

Software maintainability is defined as the degree to which an application is understood, repaired, or enhanced. Software maintainability requires more developer effort than any other phase of the development life cycle. A programming team will perform four types of maintenance on new deployments or enhancements:

- Corrective –Maintains perform in order to fix the identified bug or error.
- Adaptive – Modifications done to keep a system usable in a changing environment.
- Perfective – Correct identified errors before become an effective fault.
- Preventative – Modifications done to improve the performance

These activities will take additional time to complete **[3]**.

Data Integrity

Accuracy and consistency of data stored in a database is essential. The system in integrated with number of different types of systems. Therefore, data integrity has to be one of the main requirement that need to be satisfied. The data integrity risk can be minimized following a software development life cycle, secure communication, safe storage and technical audits.

Disaster Recovery

Disaster recovery in a system is part of security planning and is developed in conjunction with a continuity plan. Disaster recovery is a set of policies which focus on protecting an organization data and information from a disaster or negative event, which may include cyberattacks, natural disasters or device failures. Disaster recovery helps in designing strategies that can restore information, hardware, applications and data quickly for continuity.

Interoperability

The ability of a system or a product to work with other systems or products is known as interoperability. Furthermore, interoperability is the extent to which systems and devices can exchange data, and interpret that shared data without effecting the performance of the other system. The system consists of a web system standalone system and a mobile system. Therefore, it is important to maintain the interoperability. The main types of interoperability are as follows:

- Foundational – considered in data exchange.
- Structural – consider the structures of the data formats.
- Semantic – consider when two or more systems exchange and functions and processes.

Adaptability

Adaptability can be gained only if it is considered at the architecture development stage. Adaptation of software systems is an inevitable process, due to a change in customer requirements, needs for faster development of new, or maintenance of existing, software systems. Numerous techniques are developed to deal with adaptation of a systems. Most adaptability techniques are just the basics of good software design, if the techniques are applied consistently and systematically, they add up to adaptability.

Flexibility

flexibility is intending to increase or extend the functionality of the software after it is deployed, flexibility has to be planned from the beginning of the development of the system. Flexibility influences choices made during the design phase, development, testing, and deployment of the system. Flexibility is the ease with the system can be reused, deployed, and tested.

Chapter 4:Designing

4.1 Introduction

The designing stage can be divided it to main three parts as system designing, interface designing and database designing. The whole system is designed in this stage, this is one of the prominent stages in the modern waterfall model. This can be further explained as software design is the process of implementing software solutions to one or more set of problems[1].

4.2 System Development Life Cycle

The systems development life cycle (SDLC) is a conceptual model used in project management that describes the stages involved in an information system development project, from an initial feasibility study through maintenance of the completed application. Various SDLC methodologies / life cycle models described in following subsections have been considered to guide the processes involved **[9].** depending on the project type it is better to select the methodology.

4.3 Alternative Life Cycle Models

4.3.1 Traditional Waterfall model

Waterfall model consist of phases linked with each other in a sequential manner. Waterfall model demonstrate the development process more visible as the stages of the model cascade from one stage to another stage. The requirements should be clearly understood to develop the system using this model, as well as this development process model does not allow to roll back from one stage to the other. The real projects are rarely sequential and practically it is not an easy task to understand the requirements completely there for the waterfall model (figure 8) was not selected as the development process model for the smart meter and customer support system.

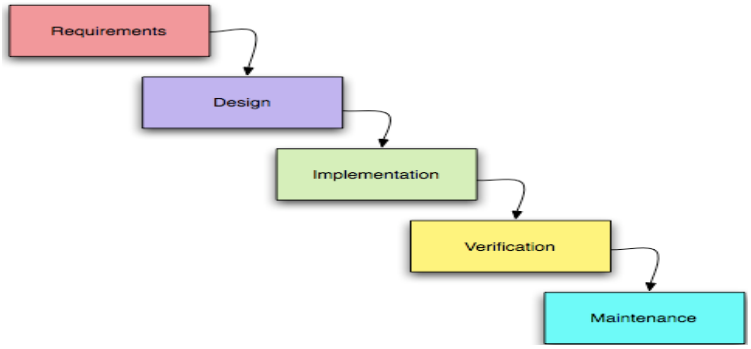


Figure 8 - Traditional waterfall model [3]

4.3.2 Prototype model

Evolutionary development is based on developing an initial implementation explore with the user comment and re-finding the requirements through many versions until an adequate system developed. The figure 9 is throw away prototype model. In prototyping the process is not visible because of the lack of deliverables. Important features of the system can be left out by using this method. The non-functional requirements which are considered as a main focus of the SMCS system cannot be adequately tested using prototyping. The effort taken to develop the prototype will be wasted and the language using for the development of the prototypes can be incompatible with the language used in the real system [2].

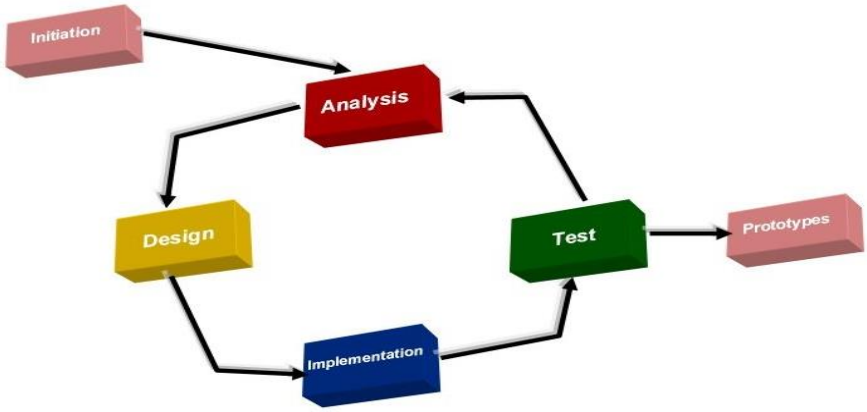


Figure 9 - Throw away prototype model [4]

4.3.3 Rational unified model (RUP)

The RUP recognizes that the conventional process model present a single view of the process in contrast, the RUP show in the figure 10 can be described by three perspectives.

- A dynamic perspective that shows the phases of the model over time
- A static perspective that shows the process activities that are in acted.
- A practice per- sportive that suggest good practice to be used during the process.

The RUP is not suitable for all types of developments and the workflows of this process are static and the technical activities are not associated with one phase there for the technical activities take place throughout the development.

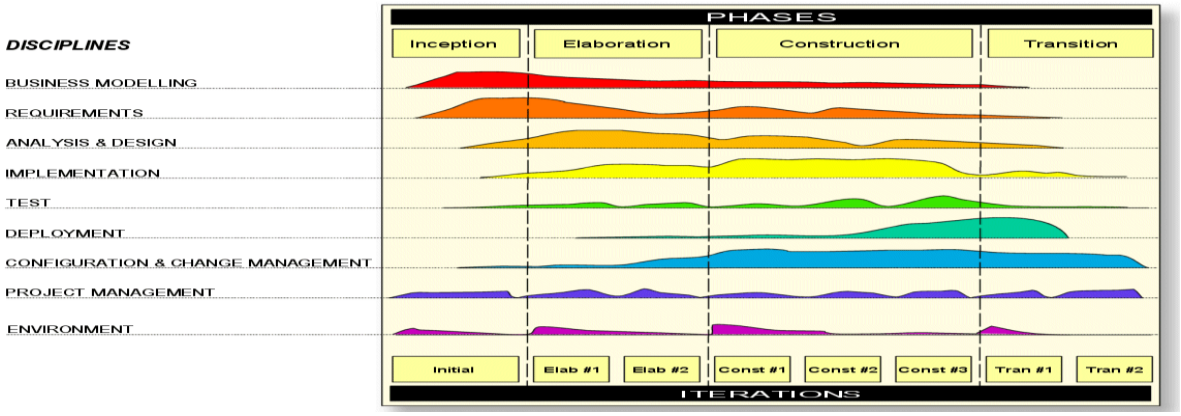


Figure 10 - Rational Unified Process model [7]

4.3.4 Spiral model

The most important distinction between the spiral model and the other process models are explicit consideration of risk. There are no fixed phases in this model management of the system development team should decide the way of structuring the project phases. Spiral model is not suitable for the SMCS system as the process model does not concentrate on the documentation, the spiral model does not match for a project which is done for an educational purpose.

4.4 Selected development process model

4.4.1 Modern waterfall model

A software development process or life cycle is a structure imposed on the development of a software product. There are several models for such processes, each describing approaches to a variety of tasks or activities that take place during the process. Modern waterfall model demonstrated by the figure 11 was selected from the above explained models.[3]

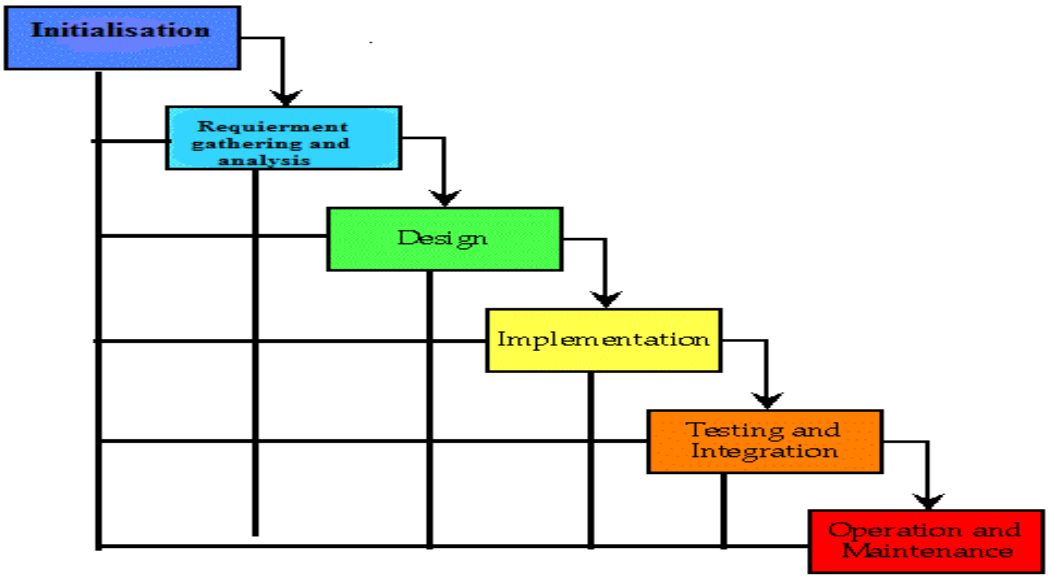


Figure 11 - Modern Waterfall Model[19]

The SMCS system is developed using the modern waterfall model which will allow iterating through phases during the life cycle. The main stages of the modern waterfall model are described below. Modern waterfall model has the ability to roll back into any stage from the current stage. The drawbacks of the models describe below can be eliminated by using the modern waterfall model. The risk allocated in the project when working with modern waterfall model is low.

There can be requirements which will change with the implementation and not very clear in the beginning of the life cycle, there for modern waterfall model is the ideal development life cycle for proposed smart meter and customer support system. The stages of the life cycle are as follows:

Initialization

The stage of initialization contains of feasibility study and the literature survey. The feasibility study is conducted to ensure the benefits and deliverables of the project are justifiable, before moving into other phases of development. Literature survey is done in order to understand the techniques and methods of the real systems by carefully observing the existing similar systems.

Requirement gathering and analysis

The system`s services constraints and goals are established by consultation with system users. They are then defined in a manner which is understandable by both users and development.

Designing

The system designing process separates the requirements in to two main parts. It establishes overall system architecture. Software designing involves representing the software system functions in a form that may be transformed in to one or more executable programs.

Implementation

The system is coded in this stage. Services can be generated and the connections of the databases and the interfaces are coded in this phase.

Testing

Individual program units or programs are integrated and tested as a complete system to ensure that software requirements have been met. After testing software system is delivered to the customer.

Maintenance

The maintenance is the longest phase of the lifecycles. This phase will be the costliest stage out of the stages of modern waterfall model.

The main reasons to select the modern waterfall model are

1. The requirements of the client were clear and confirmed.
2. Possibility of separating the system into phases.
3. The modern waterfall model enables iteration and roll back through the phases.
4. This makes the software process model more visible.
5. Facilitate better monitoring and control.

4.5 System Designing

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. System design is the process of defining the components, modules, interfaces, and data for a system to satisfy specified requirements. System development is the process of creating or altering systems, along with the processes, practices, models, and methodologies used to develop them.

4.5.1 Object oriented design

Object oriented design uses object based approach. The OOAD approach allows using reusable component and reducing the complexity of the designing [4].

4.5.2 Unified Modelling Language

Unified Modelling Language (UML) is a visual modelling language, which is used as the standard language for object oriented modelling.

4.5.3 Use case diagrams

A use case diagram displays the relationship among actors and use cases. The figure 12 explains the high level use case diagram of the smart meter and customer support system for the Lanka electricity company. Use case diagrams are used to specify

1. Requirements, required usages of a system under design or analysis to capture requirements.
2. The functionality offered by a subject.
3. Requirements the specified subject poses on its environment.

The rest of the diagrams are attached in the Appendix A

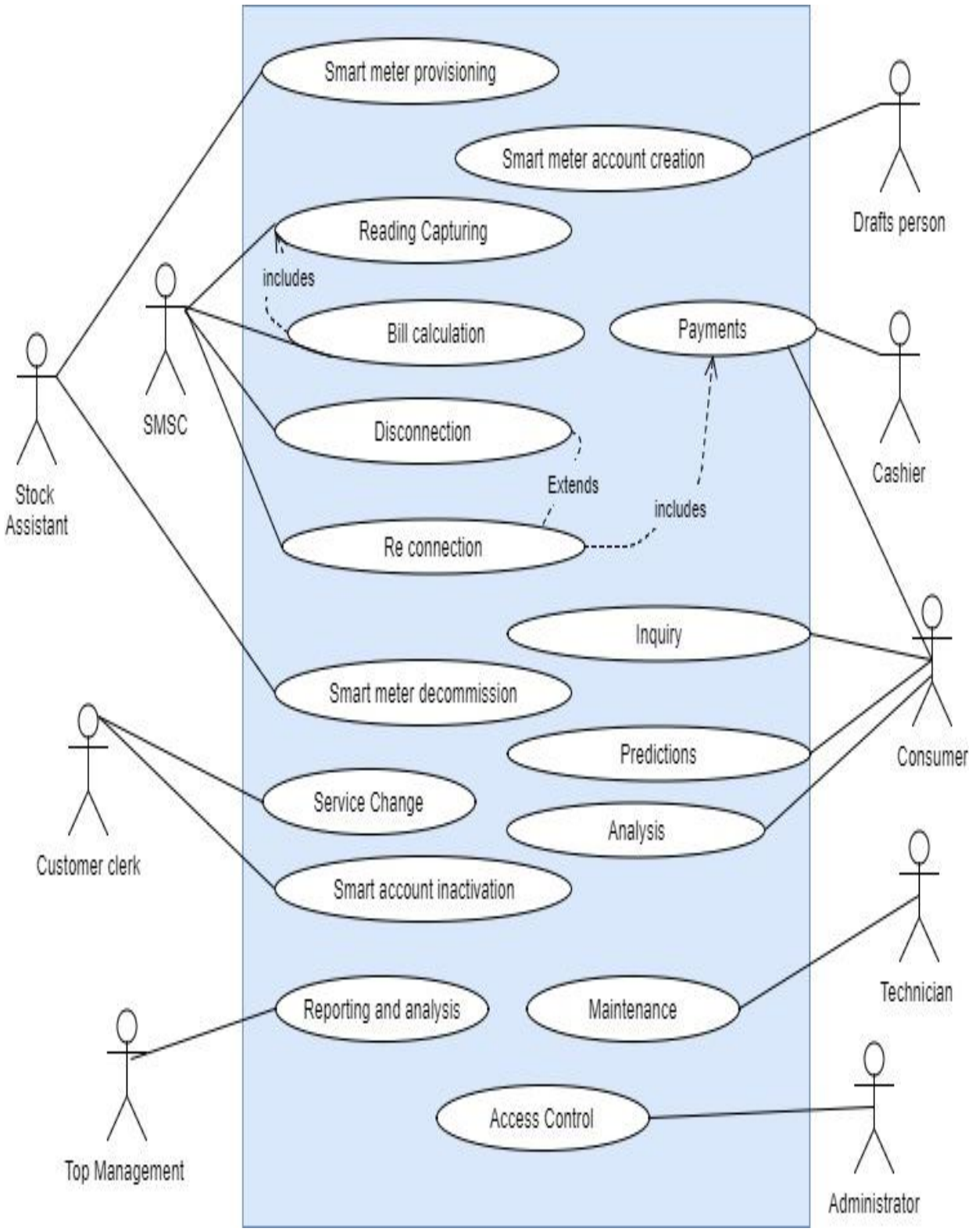


Figure 12 - High level functionalities

4.5.4 Class diagram

A UML Class diagrams are used to model static view of the system and they illustrate existing classes, their attributes and operations, and relationship among classes.

Figure 13 represents class diagram. Class diagram is a static diagram. It represents the static view of an application. Class diagram is not only used for visualizing, describing, and documenting different aspects of a system but also for constructing executable code of the software application.

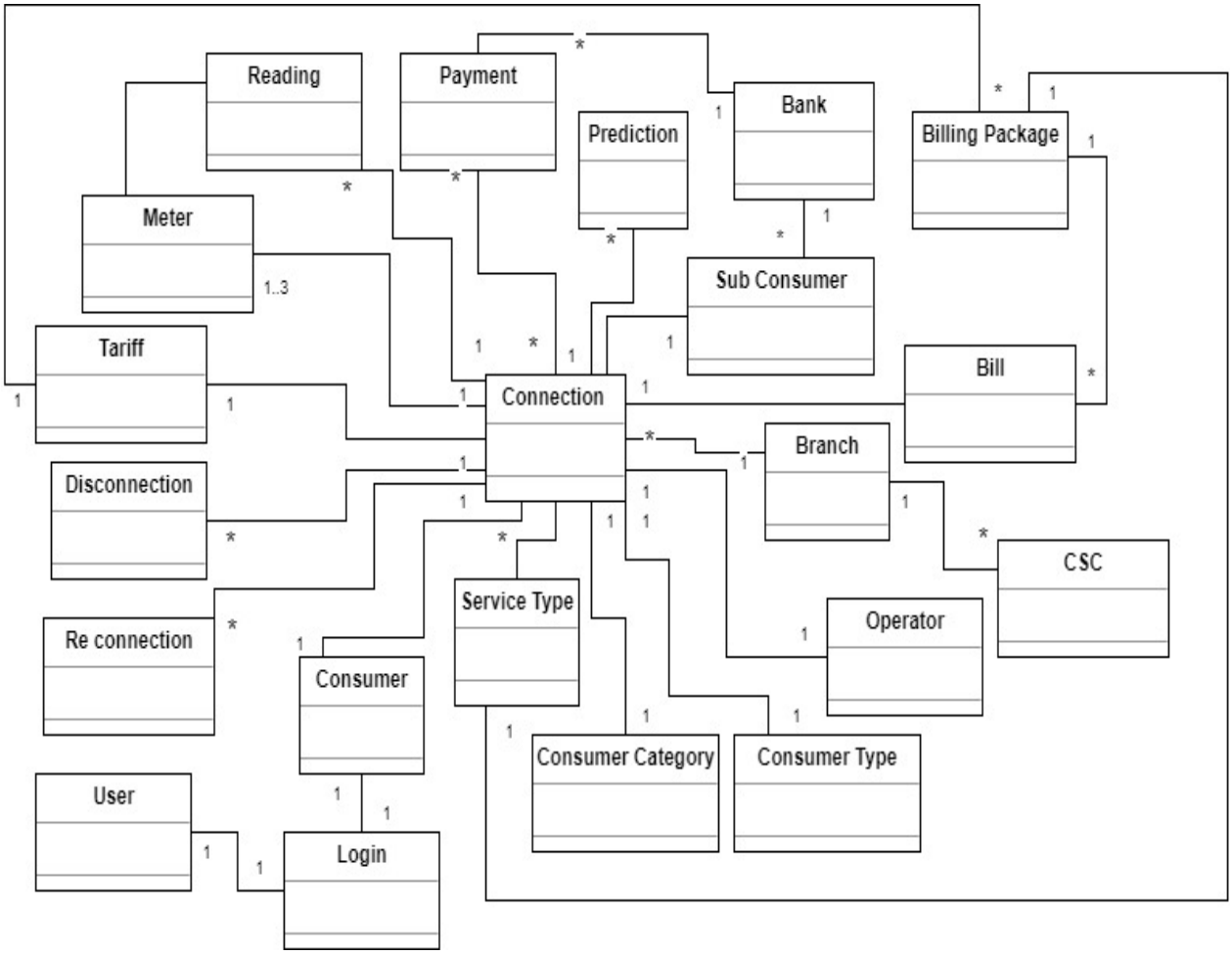


Figure 13 - Class Diagram

4.5.5 Sequence Diagram

The Sequence diagram demonstrate the message sequence of the smart meter. The Figure 14 is the sequence diagram for the smart meter communication of the system. The Smart meter is the main actor of the sequence and the proposed system and the LECO billing system act as the boundary classes. Proposed application programming interface act as control class.

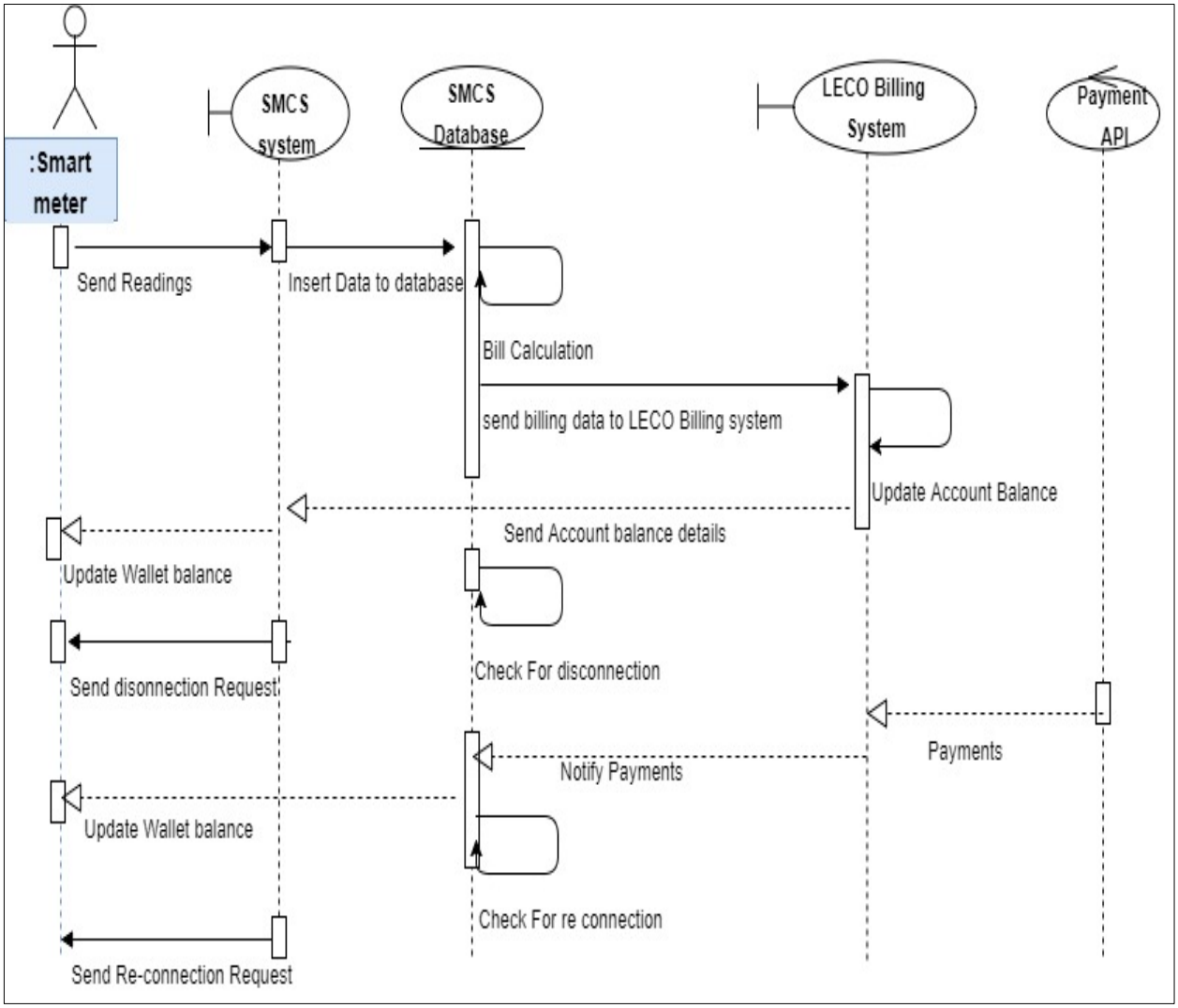


Figure 14 - Sequence diagram of smart meter communication

Chapter 5: Implementation

5.1 Introduction

The chapter discusses the implementation of the system. Section 5.2 provides the details of implementation environment of the system. Section 5.3 outlines the development tools used during the development. Section 5.4 provides an overview of the completed development process. It explains the various elements of the frameworks and libraries used to develop. Explanation of reusable components are given in Section 5.5.

5.2 Implementation Environment

Lanka electricity has standardized the use of software applications and operating systems for client machine as a result target browser has been decided as Mozilla Firefox. The Windows base application installed on windows 8 and higher versions. The android application supports from android 6.0 marshmallow and higher versions.

5.3 Development Tools

Number of tools were used throughout the project and following are used in the development stage.

5.3.1 **Database Management System**

The selected Database management system is Oracle Database 11g Release 2. The following were considered when selecting the best DBMS.

- Oracle is a database that delivers excellent performance when challenged with demanding tasks.
- The database is transformed from one valid state to another valid state. Illegal transactions aren't allowed and, if an integrity constraint can't be satisfied then the transaction is rolled back.
- Once committed (completed), the results of a transaction are permanent and survive future system and media failures and thus ensuring maintenance and protection of data.

- Efficient recovery from human errors
- Faster database recovery
- Helps in simplifying the management and administration processes

5.3.2 **Requirements for DBMS**

The table 5 shows the requirements of Oracle 11g release 2.

Framework	Oracle supports Laravel framework android and java applications frameworks
Software	Oracle support almost every type of software
Network Selection	The Oracle Net foundation layer uses Oracle protocol support to communicate with the following industry-standard network protocols: TCP/IP TCP/IP with SSL Named Pipes
Hard disk	Total ranges between 300 - 1160 MB
Memory	512 MB minimum, 1 GB recommended ,On Windows 7, Windows 8, and Windows 8.1, 1 GB minimum
Operating system	Oracle Database Client for Windows is supported on the following operating systems: Windows Server 2008 - Standard, Enterprise, Datacenter, and Web editions. Windows 7 - Professional, Enterprise, and Ultimate editions Windows 8 - Pro and Enterprise editions Windows 8.1 - Pro and Enterprise editions

Table 5 - Requirements for DBMS

5.3.3 **Implementation Language**

Oracle Database developers have a choice of languages for developing applications C, C++, Java, COBOL, PL/SQL, and Visual Basic. The entire functionality of the database is available in all the languages. All language-specific standards are supported. Developers can choose the languages in which they are most proficient or one that is most suitable for a specific task. For example, an application might use Java on the server side to create dynamic Web pages, PL/SQL to implement stored procedures in the database, and C++ to implement computationally intensive logic in the middle tier.

5.4 Development Process

SMCSS system is a system that consist of standalone, web base and android application. Java, PHP and android are the main development language used. Oracle 11g database PLSQL are used to provide database environments. Java is experienced by many developers because of its advantages. java is an object oriented language and it runs on multiple platforms. PHP language is also secure and robust although it is considered as a simple language. These advantages were played major role when selecting java and PHP as the development language. Further, Laravel framework was used as application framework and database level framework to simplify the development and operating system used in development was Windows 8 and NetBeans 8 installed in it. The frameworks and special APIs used for the development are as follows:

5.4.1 **Bootstrap**

Bootstrap is an open source toolkit for developing with HTML, CSS, and JS. Bootstrap prototype the ideas or build entire app with Sass variables and responsive grid system, extensive prebuilt components, and powerful plugins built on jQuery. Bootstrap helps to save time, customizable and protects consistency of the application. The Figure 15 shows the way bootstrap attached to webpage.

```
<head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <meta name="description" content="">
    <meta name="author" content="">
    <title>SB Admin 2 - Bootstrap Admin Theme</title>
    <!-- Bootstrap Core CSS -->
    <link href="../bower_components/bootstrap/dist/css/bootstrap.min.css" rel="stylesheet">
    <!-- MetisMenu CSS -->
    <link href="../bower_components/metisMenu/dist/metisMenu.min.css" rel="stylesheet">
    <!-- Custom CSS -->
    <link href="../dist/css/sb-admin-2.css" rel="stylesheet">
    <!-- Custom Fonts -->
    <link href="../bower_components/font-awesome/css/font-awesome.min.css" rel="stylesheet" type="text/css">
</head>
```

Figure 15 - Bootstrap

5.4.2 **Laravel**

Laravel is a web application framework with expressive, elegant syntax. Laravel aims to make the development process a pleasing one for the developer without sacrificing application functionality. Laravel is a Model View Controller (MVC) framework attached with bundles, migrations, and Artisan command line interface. Laravel offers a robust set of tools and an application architecture that incorporates many of the best features of frameworks such as CodeIgniter, Yii, ASP.NET MVC, Ruby on Rails, Sinatra. Laravel is an Open Source framework and has rich set of features which will boost the speed of web development. planning to develop a website from scratch will consume a large amount of time. Laravel saves most of the time spent on the development. The website built in Laravel is also secure. Ability to prevents the various attacks that can take place on websites is an inbuilt feature in Laravel. Laravel offers various types of features as follows,

- Configuration management
- Modularity
- Testability
- Routing
- Object Relational Mapper
- Template engine
- E-mailing
- Authentication

5.4.3 **Cording standards**

MVC Pattern stands for Model-View-Controller Pattern. This pattern is used to separate application's concerns.

- **Model** - Model represents an object or JAVA POJO carrying data. It can also have logic to update controller if its data changes.
- **View** - View represents the visualization of the data that model contains.
- **Controller** - Controller acts on both model and view. It controls the data flow into model object and updates the view whenever data changes. It keeps view and model separate.

5.4.3 **Reports – ireport**

ireport is free, open source report designer for Jasper Reports and Jasper Reports Server. Create very sophisticated layouts containing charts, images, sub reports, crosstabs. Access data through JDBC, Table Models, JavaBeans, XML, Hibernate, CSV, and custom sources. Effective sustainability reporting cycle, which includes a regular program of data collection, communication, and responses, should benefit all reporting organizations, both internally and externally. I report facilitate all the above mentioned features. I report has ability to convert repot types easily from one type to another. Convertibility is one of the key feature required for the system [16].

5.4.5 **Google map API**

The Google Maps APIs give developers several ways of embedding Google Maps into web pages or retrieving data from Google Maps, and allow for either simple use or extensive customization [**14**]. A key is required when using the google maps APIs, or other credentials, to validate the request. The API uses java scripts when embedding the map with the applications. JavaScript is the programming language of HTML and the Web. The inner workings of map types within the maps JavaScript API is an advanced topic. Developers can simply use the basic map types using Styled Maps or define customized map tiles using custom map types. Following code in Figure 16 shows the way google map is attached with system.

```
private void Loadmap() {
    editorPane = new JEditorPane();
    try {//runtime object
        Runtime rTime = Runtime.getRuntime();
        String lonlat = obj.getLocation(txtAccNo.getText().trim());
        //get location
        if (!"0.00/0.00".equals(lonlat)) {
            String url = "10.10.0.30/map/maps4.html?lon=" + lonlat.split("/")[0].trim()
                    + "&lat=" + lonlat.split("/")[1].trim()
                    + "&trans=" + txttransformer.getText().trim()
                    + "&ro=" + txtrocode.getText().trim()
                    + "&pole=" + txtpole.getText().trim();
            String browser = Read_data_fromtext();//"C:/Program Files (x86)/Mozilla Firefox/firefox.exe ";
            Process pc = null;
            try {//get runtime in browser
                pc = rTime.exec(browser + " " + url);
            } catch (IOException ex) {
                Logger.getLogger(Inquiry_GUI.class.getName()).log(Level.SEVERE, null, ex);
            }
            pc = null;
        } else {
            JOptionPane.showMessageDialog(this, "Location Not found to view the map");
        }
    } catch (Exception ex) {
        JOptionPane.showMessageDialog(this, "Location Not found to view the map");
        Logger.getLogger(Inquiry_GUI.class.getName()).log(Level.SEVERE, null, ex);
    }
}
```

Figure 16 - Google Map implementation

5.4.6 **Menu assignment**

The system was intended to be used by the user in five roles. those roles have different authorization levels to menus and functionalities that can be performed on a form. Figure 17 shows the roles in the system and tasks they can perform. User can view only the menus that they can access.

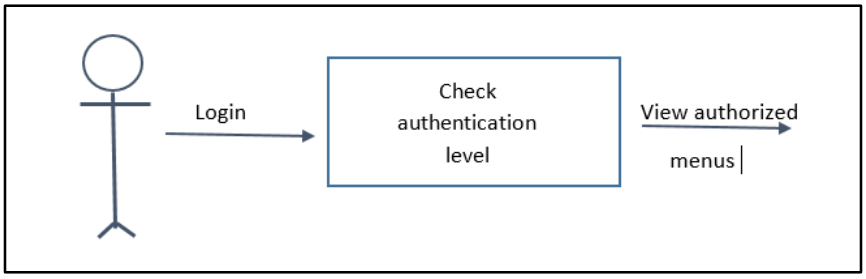


Figure 17 - Menu Assignment

5.5 Reusable components

- Date Picker

  The date picker used in the windows base application is shown below in Figure 18 The element is a reusable component which was used throughout the interfaces.

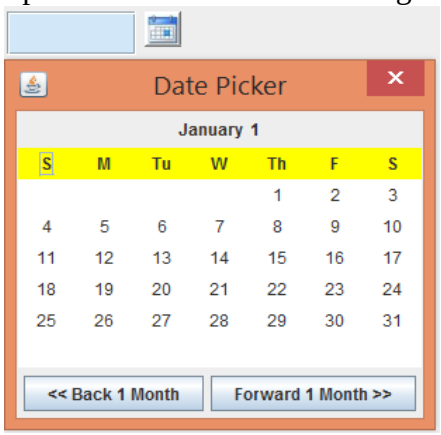


Figure 18 - Date Picker

- Menu view

  The menu view of the web application is designed on Relevel framework as a separate common blade. This is used in the web application in order to keep the consistency when navigating through pages. Figure 19 demonstrate the menu structure created. The user interface are attached in Appendix B

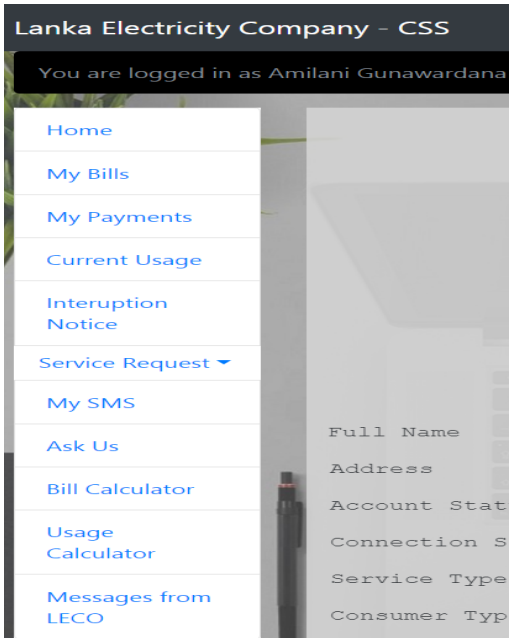


Figure 19 - Menu View

Chapter 6: User Evaluation and Testing

6.1 Introduction

Software Testing is the process of executing a program or system with the intent of finding errors or it involves any activity aimed at evaluating an attribute or capability of a program or system and determining that it meets its required results.

6.2 Testing

Testing as a whole determines whether the system us developed according to the requirement specification by going through various types of testing strategies testing ensure that users can work along with the system without producing simultaneous errors. The system errors cause system crashes and data losses which is undesirable from users point of view. Testing ensures the reliability of the delivered product of the client.

The errors explored during the testing process are traced the root and modifications done to correct errors. Proper test plans and strategies should be identified, defined and viewed according to the project.

6.3 Testing Levels

The test plans are developed along with the system planning and are carried out throughout the system development phases. The strategy will cause minimized number of runtime errors. Below in the documentation explains the testing level and the execution stages.

6.3.1 **Unit testing**

The primary goal of unit testing is to take the smallest piece of testable software in the application, isolate it from the remainder of the code, and determine whether it behaves exactly as the expectations. Unit testing has proven its value in that a large percentage of defects are identified during its use. The below Figure 20 shows the unit test code used for testing in NetBeans.

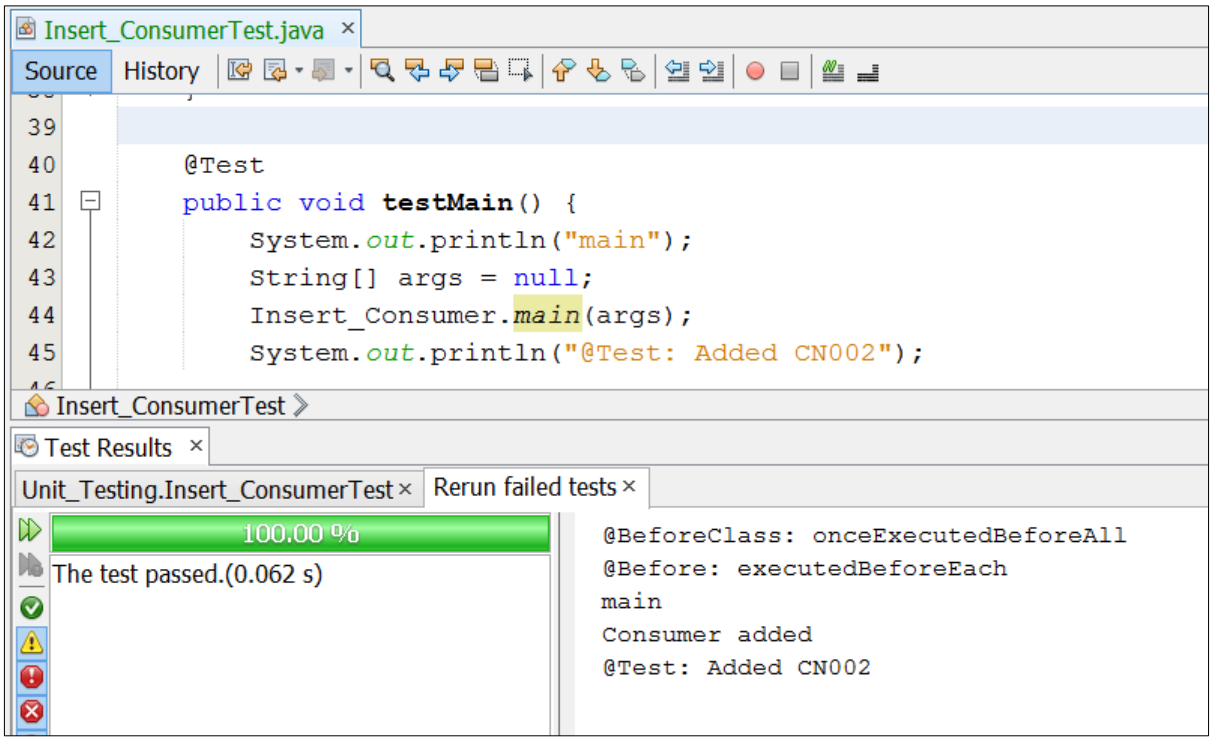


Figure 20 - Unit test code

6.3.2 **Black box testing**

Black Box Testing is also known as functional testing. In a black box test on software design the tester only knows the inputs and what the expected outcomes should be and not how the program arrives at those outputs. The tester does not examine the programming code and does not need any further knowledge of the program other than its specifications.

6.3.3 **White box testing**

White-box testing is a method of testing software that tests internal structures or workings of an application, as opposed to its functionality. In white-box testing an internal perspective of the system, as well as programming skills, are used to design test cases. The tester chooses inputs to exercise paths through the code and determine the appropriate outputs. While white-box testing can be applied at the unit, integration and system levels of the software testing process, it is usually done at the unit level.

6.3.4 **Integration testing**

Integration testing is a logical extension of unit testing. In integration testing many units are combined into components, which are in turn aggregated into even larger parts of the program. Eventually all the modules making up a process are tested together. Integration testing identifies problems that occur when units are combined.

6.3.5 **System testing**

Entire system is tested as per the requirements. Black-box type testing that is based on overall requirements specifications, covers all combined parts of a system. Impact of requirements on system testing are as follows,

- Quality of use cases determines the ease of functional testing.
- Quality of subsystem decomposition determines the ease of structure testing.
- Quality of nonfunctional requirements and constraints determines the ease of performance tests.

6.3.6 **User acceptance testing/ user evaluation testing**

User acceptance testing is done to verify the system meets the customer specified requirements. Users of the system or customer carryout this testing to determine whether to accept application. the questionnaire provided for user acceptance is attached in the appendices in the document. user acceptance testing is the set of processes of validation conducted on a system, to assess if the system works in the way that is claimed to work, and to prove that all user requirements are fulfilled. The testing will be done in two levels: first level of testing is conducted to determine if all functions of the system function as stated. Second level is to evaluate compatibility with the study protocol specifications. User Acceptance Testing should be performed compulsory, as mistakes made during creation of the database, if not corrected, could affect data storage and analysis. User acceptance testing has main 2 aspects namely Alpha and Beta testing. Alpha testing is done in development environment by the users and beta testing is performed by a selected group of actual users. The user manual of the system is attached in Appendix E in this document.

6.4 Functional Testing plan

Test plan provides the strategy for testing the project. This document provides the platform for testing the project. The objective of testing is to see if the project meets the software requirement specification. The document will provide

- the guidelines for the testing team to test the functionalities embedded in the project
- evaluating the software quality of the project.

Functional test plan is given in table 6.

Module	Test case	Priority	Acceptance	Windows/
Authentication				mobile/ web
	1.Login to system	High		WI,M,WE
	2.Change password	High		WI,M,WE
	3.Change authentication level	High		WI
	4.Create user	High		WI,M,WE
	5.Create user group	High		WI
	6.Change privileges	High		WI
New	1.Create account	High		WI
Connection	2. Activate account	High		WI
	3. Add new pole	Medium		WI
	4.allocate meter	High		WI
	5. generate relevant reports	High		WI
	6. view in inquiry	Medium		WI
Connection	1. Tariff change	High		WI
Maintenance	2.Meter and tariff change	High		WI
	3.Meter change	High		WI
	4.Meter change cancellation	Medium		WI
	5.Meter provisioning	High		WI
	6.Meter decommissioning	High		WI
	7.Consumer Name change	High		WI
	8.Ownership Change	High		WI

Inquiry	1.View provisioning history	Medium		WI
	2. Meter status	Medium		WI
	4. Account details	High		WI
Connection Close	1. Refund Process	High		WI
	2.Final statement	High		WI
	3. Account close	High		WI
Reports	1.Abnormal consumption	High		WI
	2. Reading not receiving	High		WI
	3.Overdue accounts	High		WI
	4.Pending payments	High		WI
	5.Reading Summary	Medium		WI
Payments	1.Bill payment	High		WI,M,WE
	2. Refunds	High		WI
	3.Writeoff	High		WI
	4.Transfer	High		WI
Disconnection	1.Disconnection Process	High		WI
Reconnection	1.ReconnectionProcess	High		WI
Customer Support	1. Download Application form web	High		WE
	2.Upload relevant documents to web	High		WE
	3.Complain handling	Medium		WI,WE, M
	4.View Bill Details	Medium		WI,WE,M

Table 6-Test Plan

6.5 Developer test results

Developer Testing is done by the developer in order to check the systems functionality. Junit test Framework has been used to develop the developer tests. Developer tests are written whilst the developer is writing the actual functionality. This process is tightly integrated so that the developer can work in a flow of writing tests and the logic. Most software development organizations have compelling reasons to improve quality, reduce costs, and accelerate schedules. The majority of software projects are of lower quality than desired, cost more than budgeted, and are completed later than planned. Many projects can only be branded complete failures and have to be restarted from scratch. The test results are listed under the table 7.

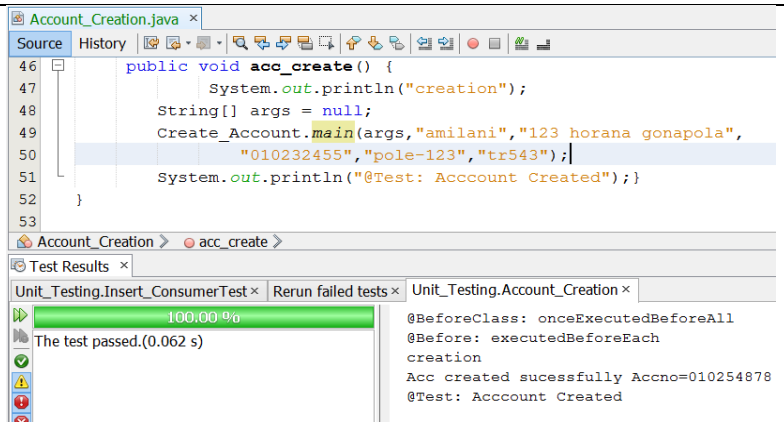
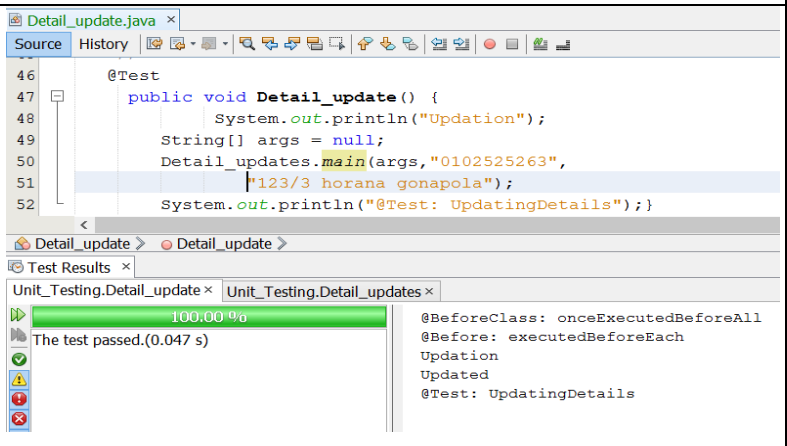
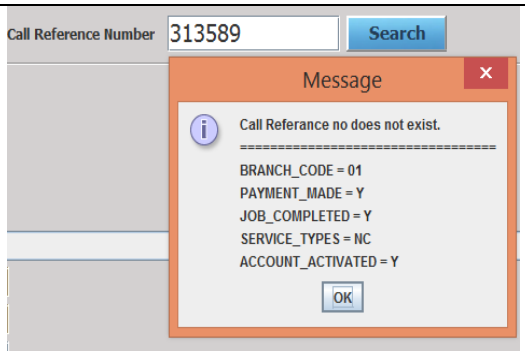
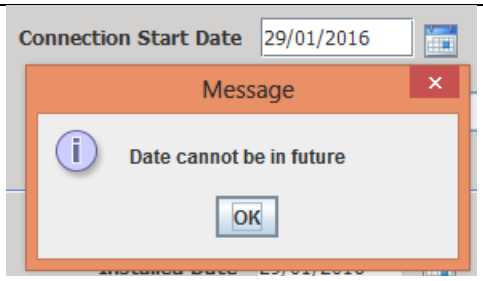
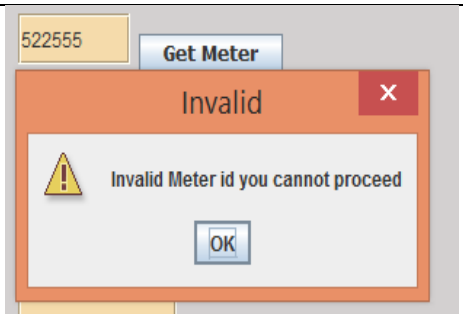
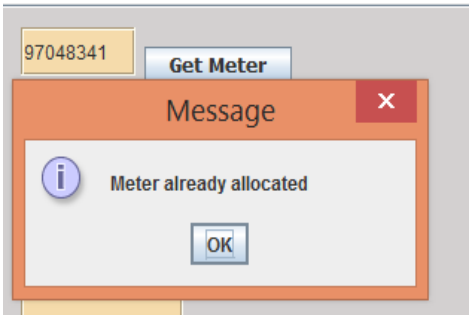
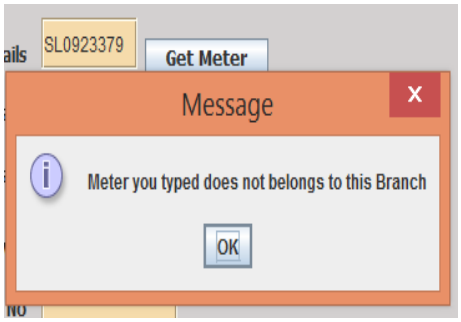
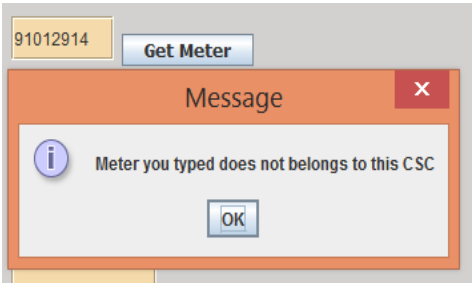
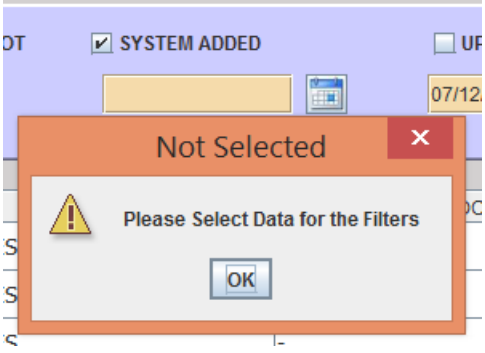
	Test Case	Expected Out Put	Actual Out Put	Statues
1	Account Creation	Pass the Unit Test		Pass
2	Update Details	Pass the Unit Test		Pass

Table 7 - Development Test Results

6.3.2 **System test results**

Testing was conducted for each part of the system. The test was done from the user login to each task of editing, deleting and adding event that will occur in the system. Testing helped to eliminate errors. The tests were done under the following situations. Incorrect input, incorrect output and incorrect process. Testing helped to find instances where inaccurate information was being displayed to the user. System testing validate and verify both the application architecture and business requirements. System testing resembles the effective production environment where the application is lastly deployed. The tables 8 show a few of the test cases used to conduct testing. The rest of the test cases can be found in Appendix D – Test Results.

Module	Test case	Result	Status (pass/Fail)
Account Creation / Account Activation	Validate call reference number The activating account should satisfy 5 main needs. 1. Valid branch 2. Payment complete 3. Job completed 4.Service type 5.Account is not activated		Pass
	Validate connection given date Future dates are eliminated in the system.		Pass

	Allocating smart meters – validate meter availability. A meter should be satisfy the following conditions in order to be allocated to an account. 1.Should be a provisioned meter. 2.Meter should not be allocated to any other account 3.meter and account should belong to same branch. 4. meter and account should be belonging to the same customer service center	   	Pass
Invalid filter selection	Select invalid filtering option		Pass

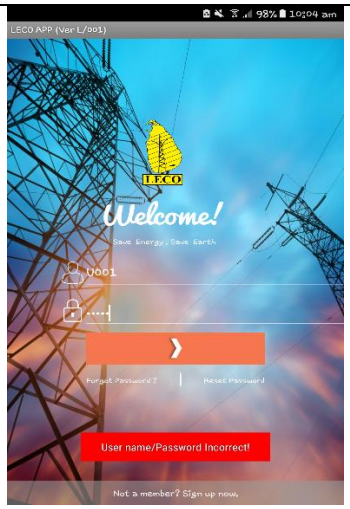
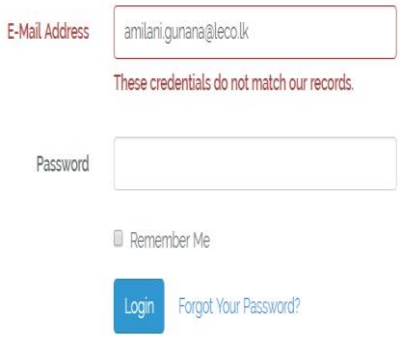
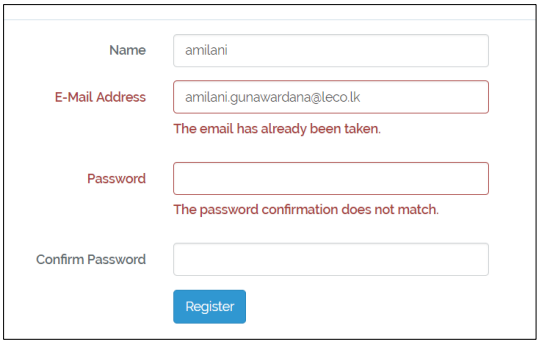
Mobile Application			
User login	Validate User 1. User should be registered in the system 2. user name and password should match.		Pass
Web Application			
Authentication	Invalid user 1. User should be registered in the system 2. user name and password should match.		Pass
Validate for empty fields			Pass

Table 8 - Customer support Test Results

Chapter 7: Conclusion and Future Work

7.1 Chapter overview

This Chapter included conclusion, challenges faced and lessons learned along with the future work of the implemented project. This chapter includes a summary of the whole thesis. Conclusion is an important part of dissertation.

7.2 Conclusion

Inspecting the project, it is clear the system implemented is highly accepted by user of LECO and the consumers are eager to be a part of customer support system.

Smart meter grid is made up of a set of smart meters, communication modules, Local Area Network (LAN), Data Concentrator (DC), Wide Area Network (WAN), Meter Data Collection System and Meter Data Management System Smart meters are able to measure parameters such as total harmonic distortion, power quality parameter, power factor in addition to conventional parameters such as voltage and current. Manipulation or tamper of smart meters can be detected and are able to report. Smart meters system prepares useful data for energy management. Smart meters show the real consumption cost, register the data associated to consumption, connect consumers, or disconnect automatically from the power grid. Communication technologies can transmit control signals and commands issued from the central system to smart meters, and sending back the registered data from the meters to master station and control center. Smart meter solution integrates multiple meter data collection systems, billing data, distribution management data, and makes sophisticated process of meter data.

Smart metering related business process included in the system can realize as follows,

- Centralized and remote meter reading.
- Remote control.
- Remote auto-recharge.
- Remote download rates set/load control threshold.
- Remote authorized changing meter operating parameters.
- Installation and whole life cycle.
- Managing meter user information file.

- Initiatively reporting the grid line loss and abnormal events.
- Connecting with the national payment system.
- Power company management system.
- Providing power company managements with the statements and data.

The smart meter offers possibilities to offer new and dedicated services to their customers. The smart meter may become a gateway into the home of the customer, to provide new value added customer services such as the billing process, real consumption data can be used, simplifying the current process of advances and recalculation. Mobile application and web application proposed to develop should facilitate the above mentioned scenarios. The consumer support should be available consistently. The payments done through the web application should connect with a payment gateway the securities of the transactions need to be addressed as a priority. Introduction of smart metering is a logical step in a world where all communication is digitalized and standardized (Internet, E-mail, SMS) and where cost of 'digital intelligence' are still rapidly decreasing. Moreover, an advanced metering infrastructure offers more than just reading and controlling smart meters. The system dedicated gateway to the customer's home, offering additional energy related services. The system can be used for stimulate the customer to change the energy behaviour and control of household appliances in relation to local generation of electricity. SMS gate way connectivity has to build up during the installation.

The system consists of a standalone system that supports LECO employees, web application and mobile application that provides customer supports system. Firstly, the feasibility study was conducted to ensure the benefits and deliverables of the project are justifiable, before moving into other phases of development. Considerable amount of project time period was devoted for system analysis and design phases. System analysis stage included different fact gathering methods were used and interviews, questionnaires and observation as main techniques. Frequent requirements reviews were conducted to ensure accuracy of gathered requirements. The major effort was given to gather the exact user requirement. The newly implemented features were finalized by the engineering head and the team and was clearly delivered the requirement to the development unit. The similar systems implemented in China and Canada was examined in order to gather the actual need and functionalities of smart metering system. Several diagrams were drawn at the design phase such as use case diagrams, sequence diagrams, activity diagrams etc. to cover all major

functional areas of SMCSS system. Modern waterfall methodology and object oriented modelling were selected to design and develop the system after considering several alternatives. Database was design according to third normalization form and database diagram was drawn to reflect relationships among tables. Simple and consistent theme was applied to reduce the complexity of interfaces. System was developed using Java language, PHP and android, security and object oriented support were considered when selecting Java language. Database was designed using Oracle 11g version server and reports were generated using ireport Report. The above mentioned libraries were selected as the have satisfactory support to Java and PHP language. Laravel framework was used to simplify the development effort. Interfaces of the web application was developed using html and Laravel framework. System testing was started in development phase, although test cases were developed in design phase. Unit testing was carried out in parallel with the system development and other test phases such as system testing, acceptance testing etc. were conducted in evaluation phase. Test cases were documented and expected outcome was compared with actual out come to ensure that the system is operating as intended.

Customer service management is based on customer, as survive is made in the global market and focused on the customer and the customer is becoming a key factor for the small and big companies. The companies know that its cost is more to acquire a new customer than to get an existing customer for a making a purchase. Smart meter system will not be a success if the customer support is not provided sufficiently. Success of the developed system mainly relay on the acceptance of the consumer. The smart meter grid concept was highly accepted in other countries as it was given with good customer support. Smart metering is a technology which is essential in the road to smart grids and to the integration of active customers to the electrical networks and to the market. The penetration is increasing quite rapidly in Europe due to the European legislation. At the moment countries are in different stages, some countries have already almost 100% penetration and some are in the experimental phase. Cost-benefit analyses show in most cases that smart metering is in most cases economically feasible if the benefits to all stakeholders and to society is taken into account. It is important to develop standardization and functional requirements to such a direction. The smart metering experience is given to the consumers in a smooth way through this system. The knowledge gathered from the subjects such as Rapid application development, mobile application development, networking database management system and project management learned from the Masters of Information technology was a great help for the success of the project.

7.3 Challenges and lessons learned

Application of security to the applications are essential, giving access to multiple users who are involved in the different tasks has to be done carefully. It is necessary to work with the latest technologies as there are so many new technologies introduced. In the beginning the selected PHP language was not sufficient to implement the web based system as there has to be a bulk of features to be added to as it is a public site. There for Laravel framework was integrated to overcome the difficulties. The knowledge gained from the masters degree was practically applied during this project. The way of adapting to the rapid changes of the client requirements lead to be open to change and the way of dealing with the situations was understood. The knowledge gained from various recourses was not correct, at a given time, under special, specific conditions. Work with the limited range of resources that are available is one of the best learnt. Paperwork and documentation are necessary for reporting purposes. The knowledge of using the development tools and the frameworks were gained. The knowledge of applying the technology with the real world events was clearly understood. The reactions of the technical and non-technical problems, facing the difficult situations such as loss of data due to a small mistake done while developing was experienced. System was developed according to the Object Oriented techniques. Further the suitable procedures, techniques and tools were used accordingly to deliver this project. Integrating web application mobile and windows application is not an easy task, different types of platforms act differently in preforming. LECO is using oracle database and setting up connectivity for the web environment were difficult as most of the web application development environments supports MySQL database. Developing and integrated system has to be done with broad knowledge and clear technical support. Project reached to the end and it was felt that the project has been a success, since it achieved proposed functional and non-functional requirements. The smart meters currently support domestic consumers only, this will be expanded to the net meter consumers in future where meter generates two readings at a time. However, this can be further improved and the suggestions are given below.

7.2 Future Work

Future enhancement need to be implemented to the system. The network has struggled over the years to keep pace with advancements in smart metering technology. The fact that smartest meter devices are designed to connect to the Internet only exacerbated the problem. The connectivity will be directly affected with the increasing number of consumers in future. Bandwidth, speed, and range to handle new technologies such as smart locks, lights, and more technologies will be needed to connect the billing system and the meter together accurately. Future enhancements need to be done to the windows base application by converting it to web base. Stand-alone systems are becoming more ordinary and as a future enhancement it will be beneficial to convert the system to web base system. The employees will enjoy the work from home facility with the web base system. LECO has less resources to provide online facilities to employees. LECO will expand the application to web based in near future. Expected to expand the system features to mobile application to support real time updating.

Smart metering system can be expanded to smart home system. Smart home system will allow to control each device in electrical circuit individually. The consumers will get the ability to control switching in a place remotely using the customer support module. More security features such as biometric will be implemented to the system. The customer support system will be expanded with the real time chatting facility. The smart metering system can be implemented to water board as well and as a result both water and electricity customer support can be provided in a same platform as a full service provider model. Consumers will have one login to access both the water accounts and electricity accounts. Alert system for abnormal consuming smart meters can develop. The abnormality in a meter will immediately informed to the branch office or the head office with the new enhancement. The unauthorized connections and defects in meter can early identify with the system, Smart metering and customers support will be an interesting and exciting application with the further enhancements.

References

BOOKS

[1] *J.L. Whitten & L.D. Bentley, Systems Analysis and Design Methods. 7th edition (Indian Edition), Tata McGraw-Hill, 2007.*

[2] *I.Sommerville, Software Engineering, 9th edition, Addison-Wesley, 2011.*

[3] *Roger S. Pressman Software Engineering, 7th edition, Addison-Wesley, 2016.*

[4] *Grady Booch, Object-oriented analysis and design with applications, 3rd edition , 1999*

ONLINE RESOURCES

[5] *2018 Project Smart. ProjectSmart.oc.uk "SMART Goals" by Michel Reader* [Online document].
Available : *http://www.projectsmart.co.uk/smartgoals.html. [Accessed 29.07.2017]*

[6] *Mr. Gordon Moore 2012 Systems Development Life Cycle(SDLC) [Online].*
Available : *http://www.mariosalexandrou.com/methodologies/systems development-life-cycle.asp [Accessed 20.04.2017]*

[7] *Dr. Jahangir Alam Assistant Professor, Aligarh Muslim University, Aligarh UP, India Spiral model [Online].*
Available : *http://users.csc.calpoly.edu/~jdalbey/308/Lectures/SoftwareProcessModels.html [Accessed 21.4.2017]*

[8] *Velma Latson. Lecturer Computer Technology, Bowie State University, USA Software Prototype Model[Online].*
Available: https://www.tutorialspoint.com/sdlc/sdlc_software_prototyping.html [Accessed 21.4.2017]

[9] *psoug.org - 2016 Oracle database normalization[Online].*
Available: *http://psoug.org/reference/normalization.html [Accessed 2.5.2017]*

[10] *Arthur.D.W Stack Overflow java development 2017 para 4[Online].*
Available: *https://stackoverflow.com/questions/tagged/java [Accessed 6.5.2017]*

[11] *Jiantao Pan 1999 Carnegie Mellon University Software n Testing [Online].*
Available: *http://www.ece.cmu.edu/~koopman/des_s99/sw_testing [Accessed 8.06.2017]*

[**12**] *Powerline Communication (PLC) solutions yitran smart meter by ysolutions[Online].*
Available: *http://www.yitran.com/index.aspx?id=3353 [Accessed 05.12.2017]*

[**13**] *Spintelligent (PTY) Ltd,unless specified otherwise 2018 Meeting and smart[Online].*
Available: *https://www.metering.com/[Accessed 05.12.2017]*

[**14**] *Copyright 1999-2018 by Refsnes Data. All Rights Reserved. Powered by W3.CSS Google_map_API-W3schools[Online].*
Available: *https://www.w3schools.com/google_maps_intro.asp [Accessed 12.12.2017]*

[**15**] *stjayasooriya - Lanka electricity company private limited[Online].*
Available: *http://leco.lk[Accessed 01/02/2018]*

[**16**] *TIBCO Software Inc ireport[Online].*
Available: *https://community.jaspersoft.com/documentation[Accessed 31/01/2018]*

[**17**] *Queen's Printer for Ontario, 2018* Smart grid fund [Online].
Available: *https://news.ontario.ca/mei/applications-now-open-for-smartgrid-fund.html [Accessed 31/01/2018]*

[**18**] *Repairable Systems Analysis Through Simulation chapters. Reliability[Online].*
Available: *http://reliawiki.com/index.php/Basics_of_System_Reliability_Analysis [Accessed 31/01/2018]*

[**19**] *David Olson 2013, 2014, 2015, 2016 Modern waterfall model[Online]*. Available *: http://bawiki.com/wiki/concepts/sdlc-process-models/waterfall/ [Accessed 31/01/2018]*

Appendix A – UML Diagrams

Use case Diagrams

Use case diagram for payment module is shown in Figure 21 and use case narration in table 9 respectively. Payment module is handled by the consumer. The consumer pay money online and the smart meters will then perform the reconnection process.

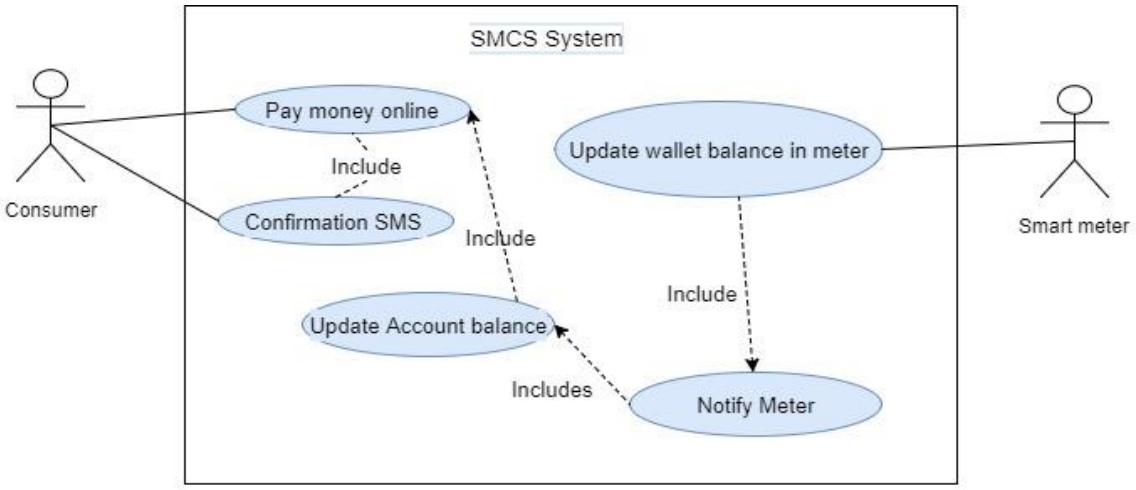


Figure 21 - Use case diagram for payments

Use case	Payments online	
Actors	Consumer	
Description	Do payments to the system using online methods	
Pre- condition	Customer should have a valid consume account of LECO	
Course of events	Actor	System
	1.login to system	2.Validate login
	3.enter the details	4.Validate details
	5. confirm payment	6.update system account balance
	8.update wallet balance	7.notify meter
Alternative courses	Alt. 4. Give error message if the username is not available 5. Prompt error message if the passwords do not match.	
Conclusions	Successfully updating the account balance user will conclude the process	

Table 9 - Use case narration for Payments module

Use case for Meter provitioning is shown in Figure 22. Meter become eligible to allocated to meters once the provisioning is successful. The smart meter system allows users to provision meters as bulk or as individual meters.

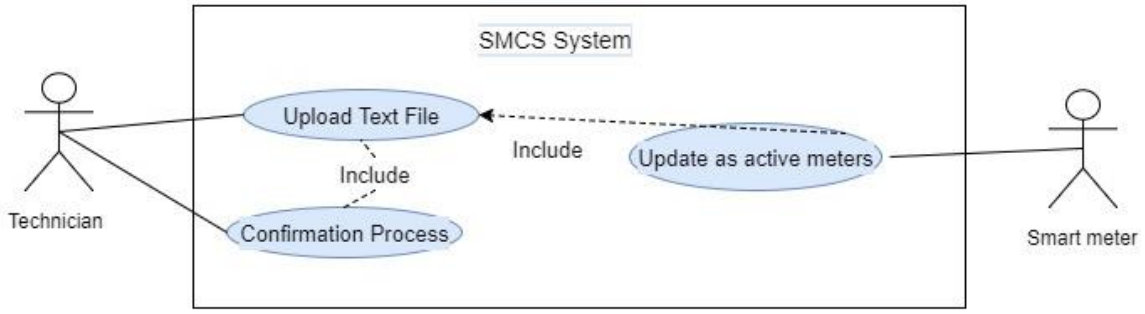


Figure 22 - Meter provisioning

Use case for smart meter account creation is in Figure 23 and use case narration in table 10 respectively. Smart meter account will be eligible for the billing process once the account is created. Account creation is done by draftsperson in LECO.

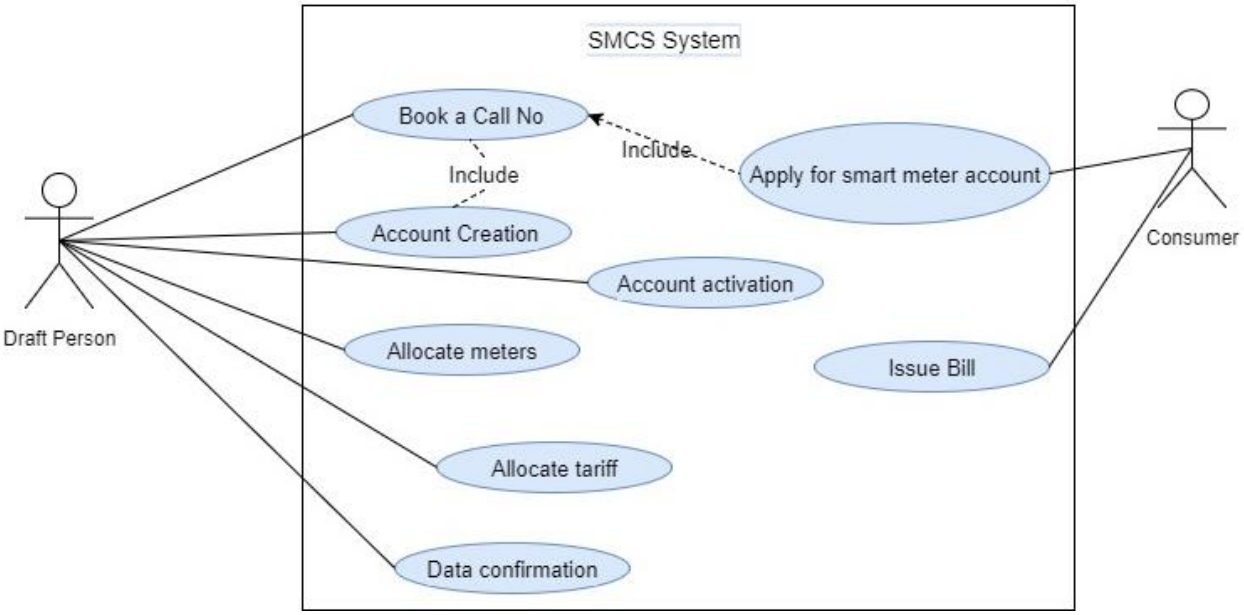


Figure 23 - Account Creation

Use case	Account Creation	
Actors	Draft Person	
Description	Creating a smart meter account	
Pre- condition	Customer should have a call no	
Course of events	Actor	System
	1.login to system	2.Validate login
	3.enter the details	4.Validate details
	5. confirm submission	6.insert data to the system
	8.reconfirmation	7.Activated account
Alternative courses	-	
Conclusions	Successfully creating the account will conclude the process	

Table 10 - Account creation use case narration

Use case diagram for service change is in Figure 24 and use case narration in table 11 respectively. Service change is used when a normal consumer in converting to a smart meter consumer.

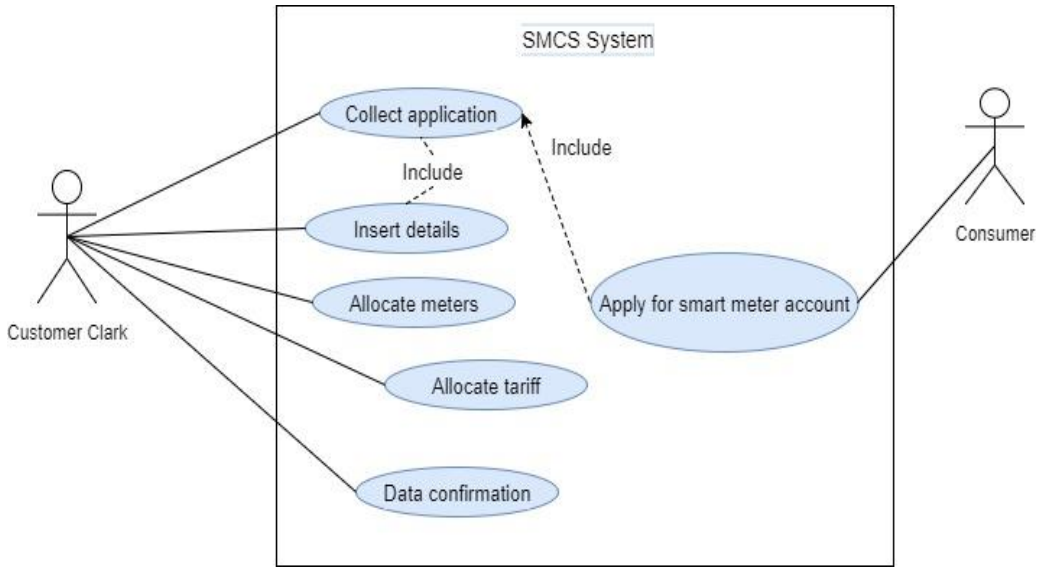


Figure 24 - Service Change user case diagram

Use case	Service Change	
Actors	Customer Clerk	
Description	Change the connection of an existing consumer to a smart meters	
Pre- condition	Customer should have a LECO account	
Course of events	Actor	System
	1.login to system	2.Validate login
	3.enter the details	4.Validate details
	5. confirm submission	6.insert data to the system
Conclusions	Successfully updating the account as a smart account will conclude the process	

Table 11 - Use case narration for service changes

Flow Diagrams.

Flow diagram for Reconnection module is shown in below Figure 25. Reconnection of the smart meter happens with the payment and reconnection request.

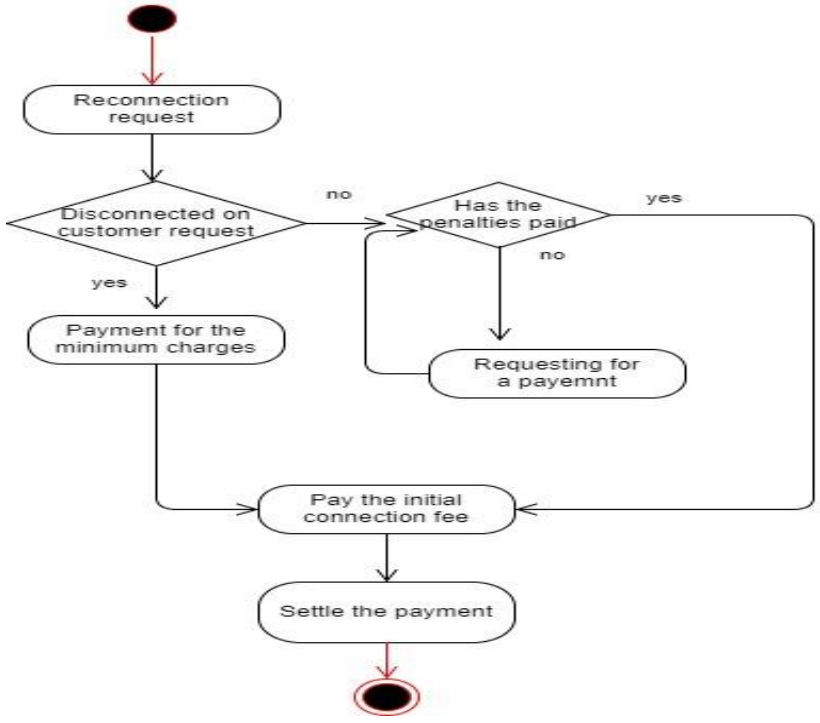


Figure 25 - Reconnection Process

Flow diagram for billing module is shown in below Figure 26.

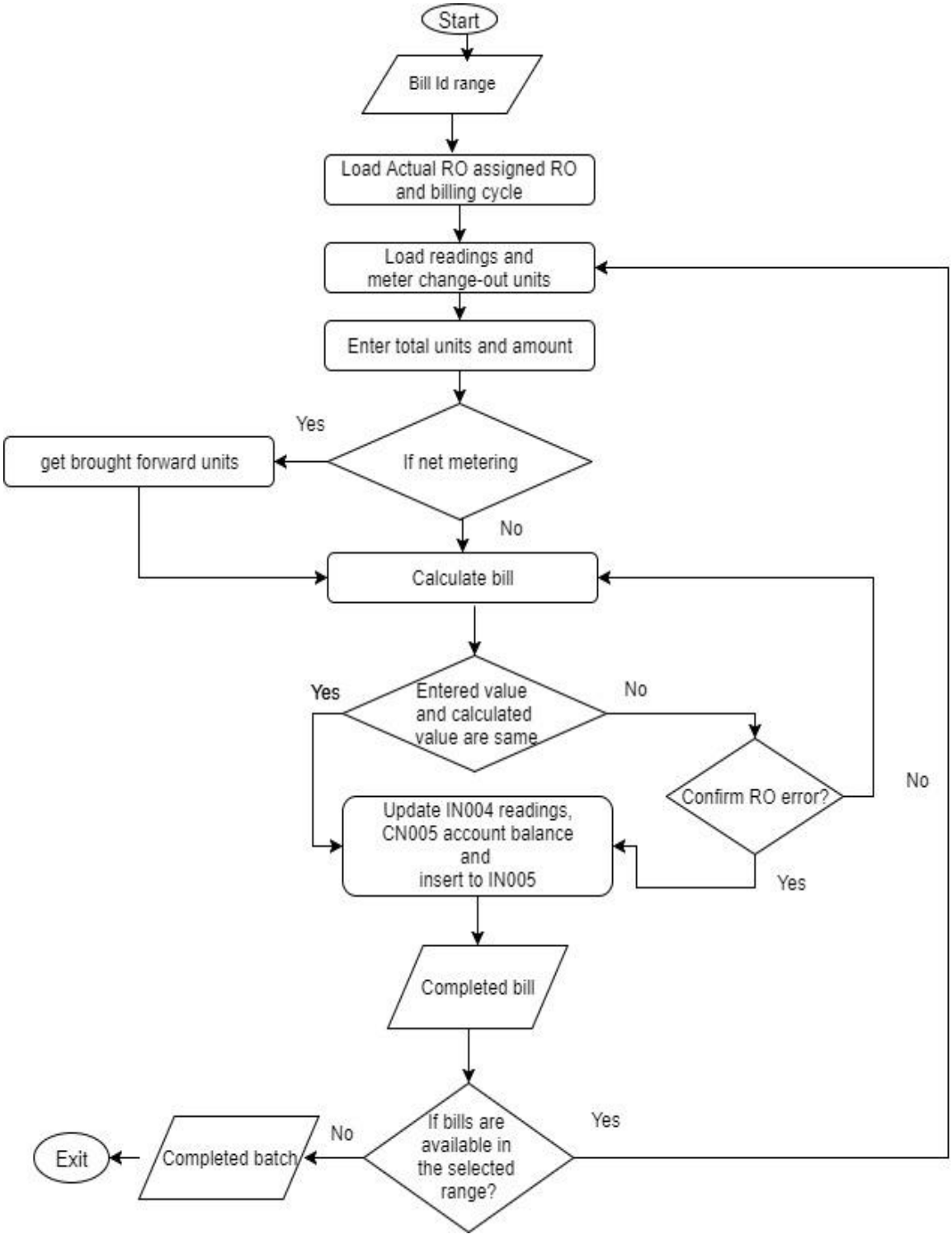


Figure 26 - Billing process flow chart

Flow diagram for billing module is shown in below Figure 27.

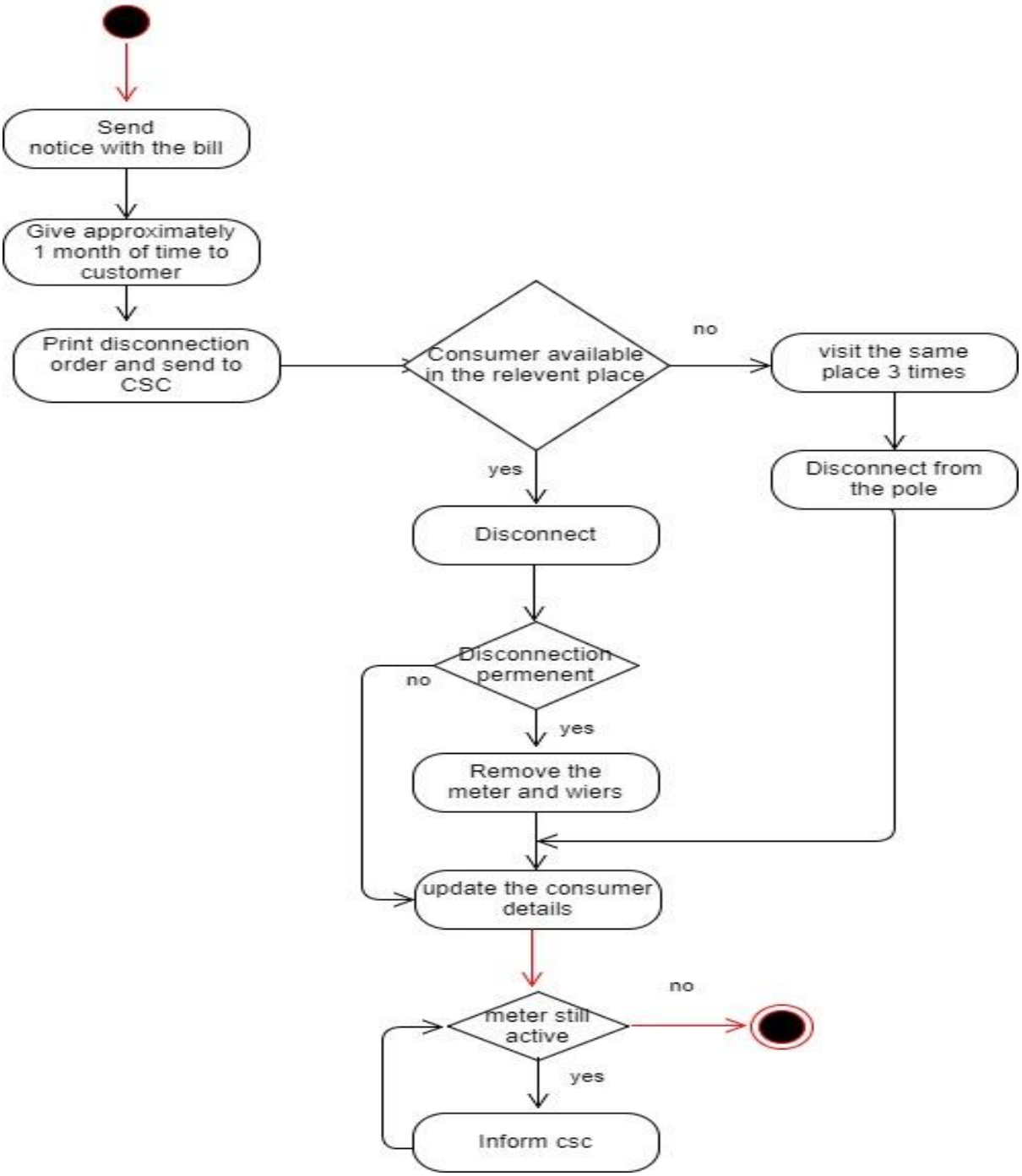


Figure 27 - Billing Module

Flow diagram for Service Change module is shown in below Figure 28.

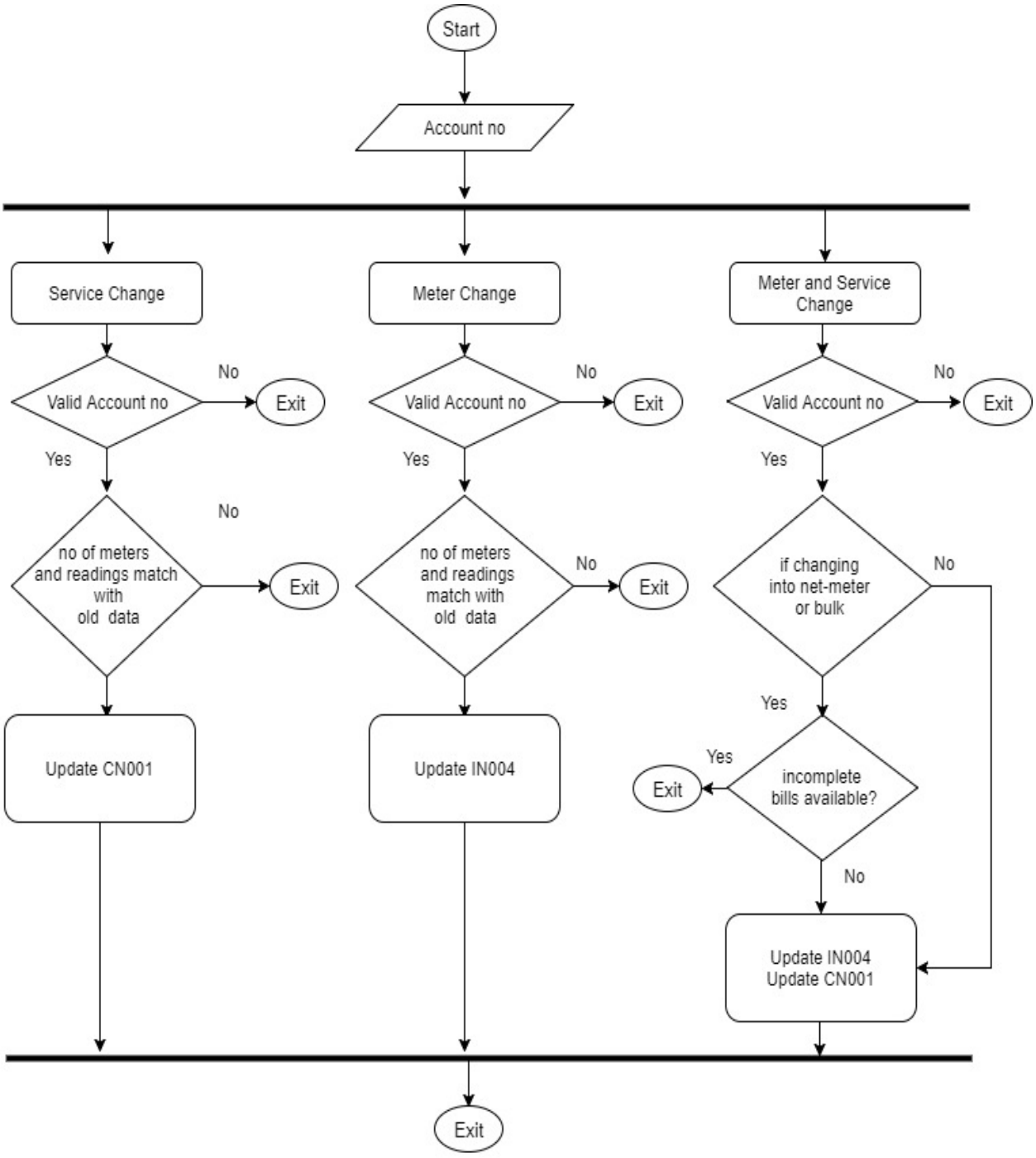


Figure 28 - Service Change

Appendix B – User Interfaces

Designed Interfaces.

Consumers details need to be changes when converting a normal consumer to a smart meter consumer. Package change interface is below in Figure 29.

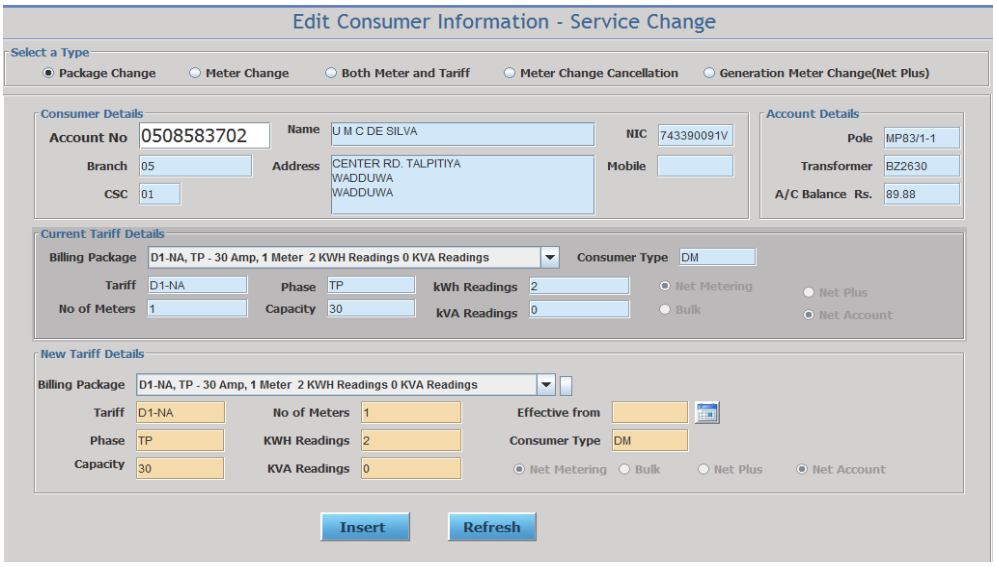


Figure 29 - Package Change

Meter change is done when smart meter is found defected and when the meter is replaced with another one. The interface is below in Figure 30.

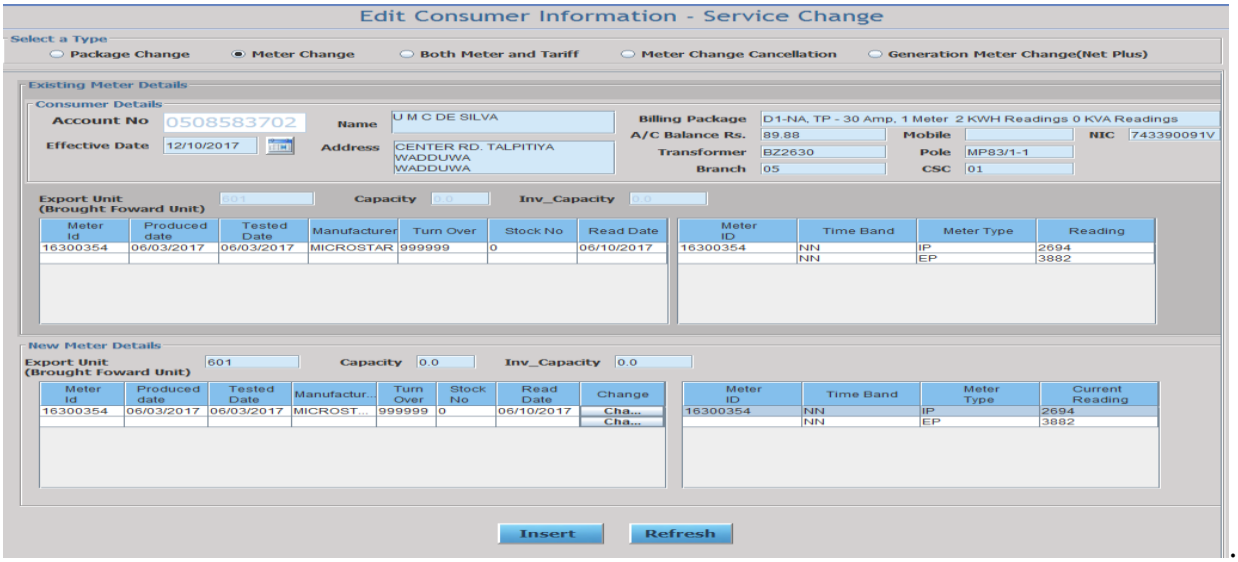


Figure 30 - Service Change Interface

Figure 31 is the interface for account creation. Account will be eligible for billing process once the account is activated.

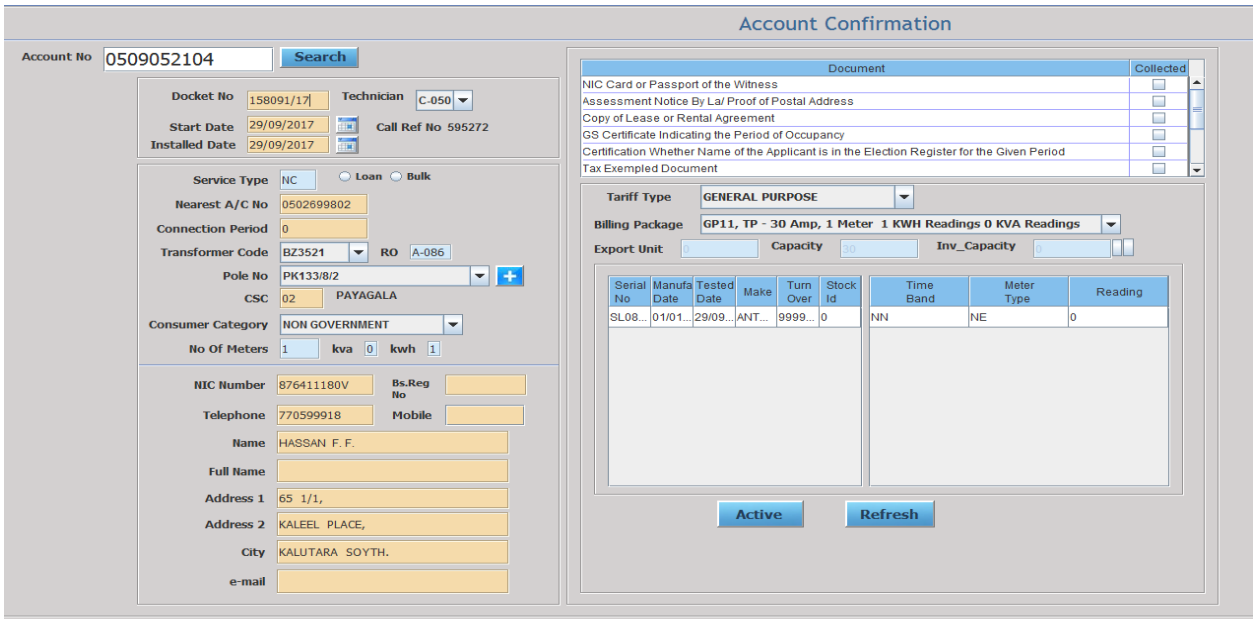


Figure 31 - Account Creation Interface

Main page of customer support system is demonstrated in Figure 32. The main page demonstrates the initial details of the consumer.

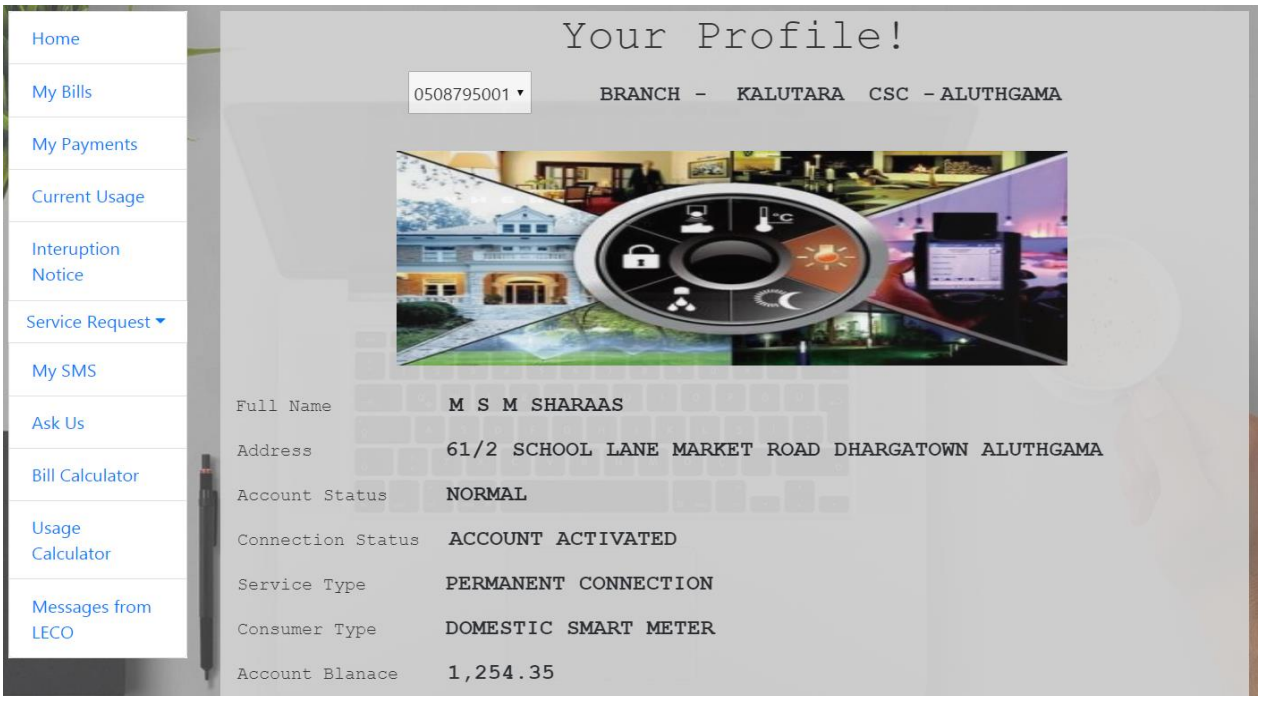


Figure 32 - Customer Support System Main page

The Figure 33 is the SMS details of the consumer.

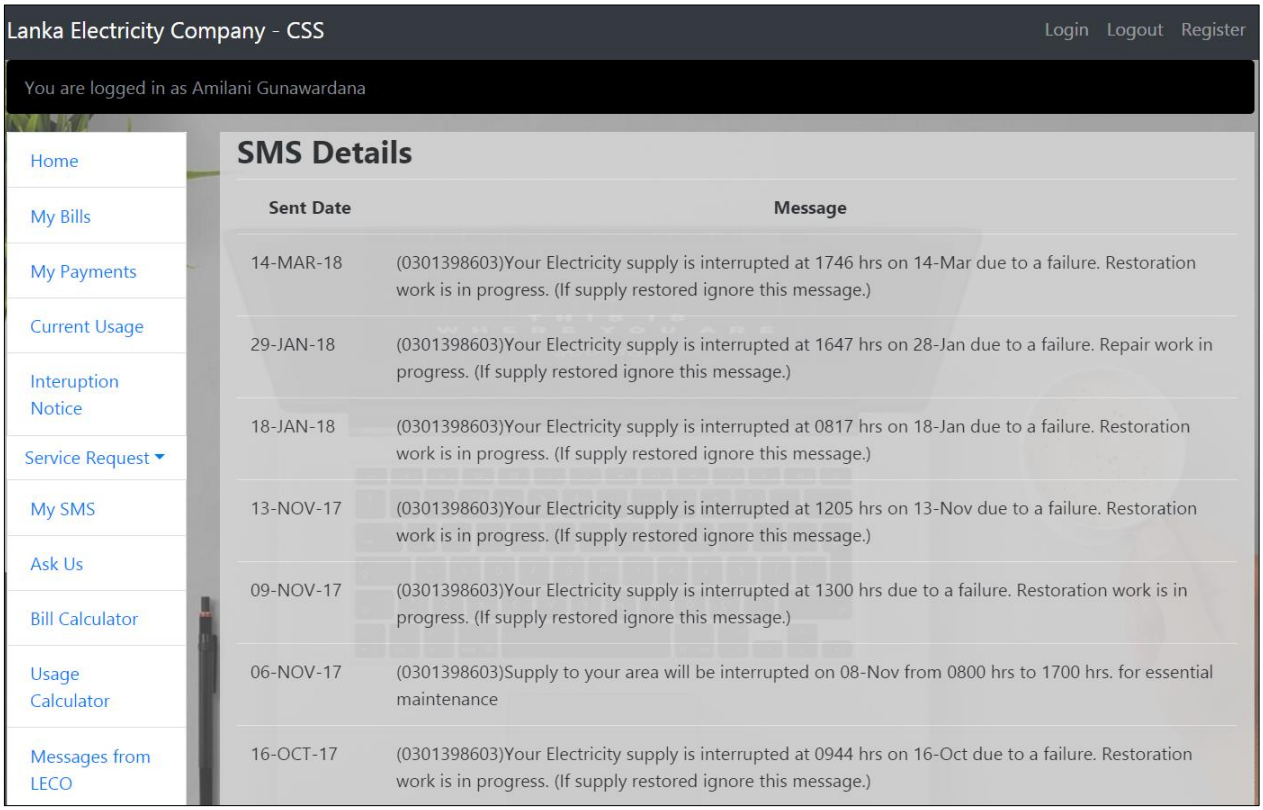
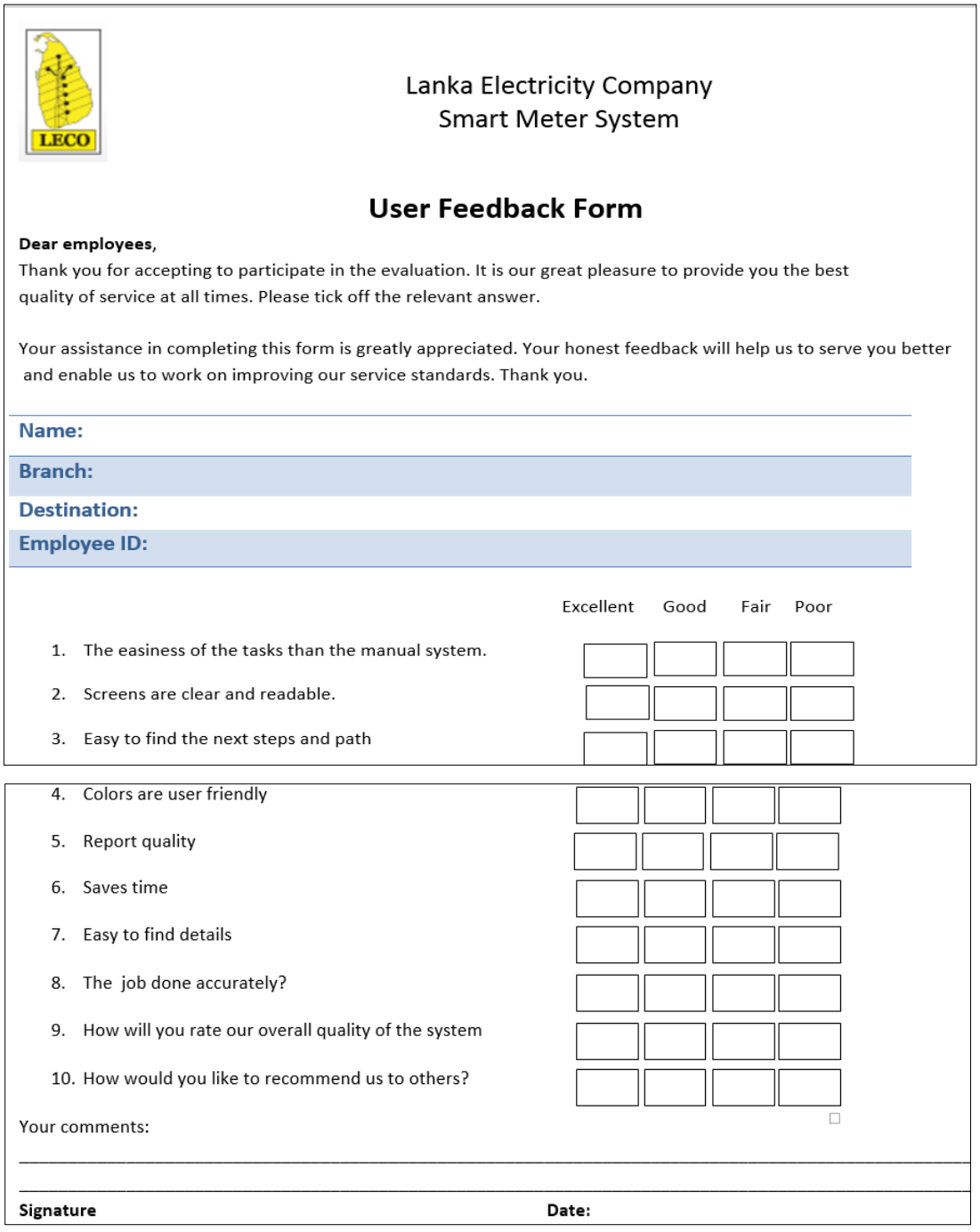


Figure 33 - Web application Interface

Appendix C – Questioner

Figure 34 demonstrate the questioner given to the user evaluation of LECO.



Lanka Electricity Company
Smart Meter System

User Feedback Form

Dear employees,

Thank you for accepting to participate in the evaluation. It is our great pleasure to provide you the best quality of service at all times. Please tick off the relevant answer.

Your assistance in completing this form is greatly appreciated. Your honest feedback will help us to serve you better and enable us to work on improving our service standards. Thank you.

Name:

Branch:

Destination:

Employee ID:

	Excellent	Good	Fair	Poor
1. The easiness of the tasks than the manual system.				
2. Screens are clear and readable.				
3. Easy to find the next steps and path				
4. Colors are user friendly				
5. Report quality				
6. Saves time				
7. Easy to find details				
8. The job done accurately?				
9. How will you rate our overall quality of the system				
10. How would you like to recommend us to others?				

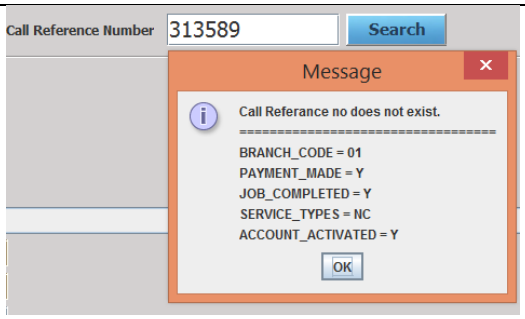
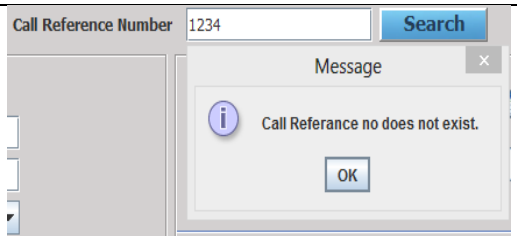
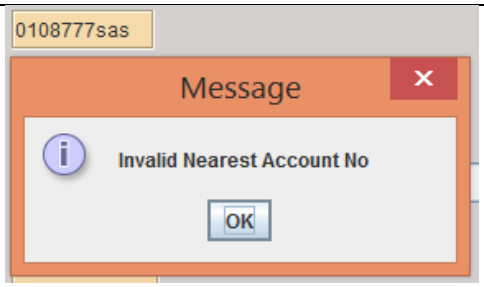
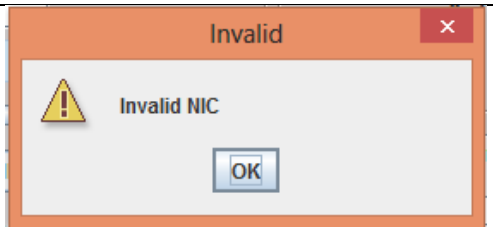
Your comments:

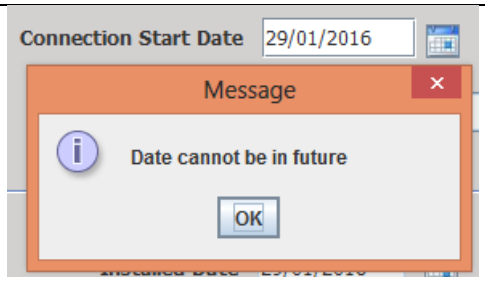
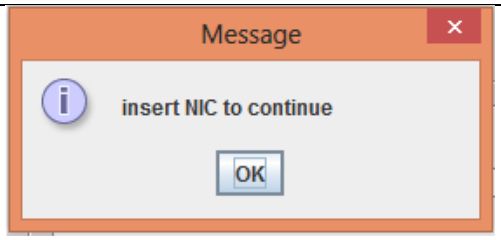
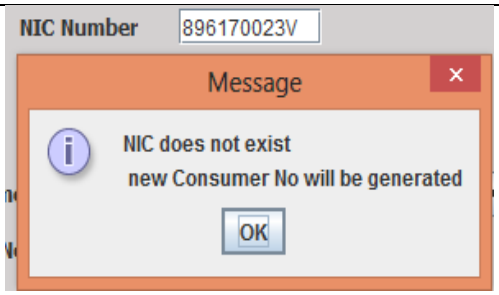
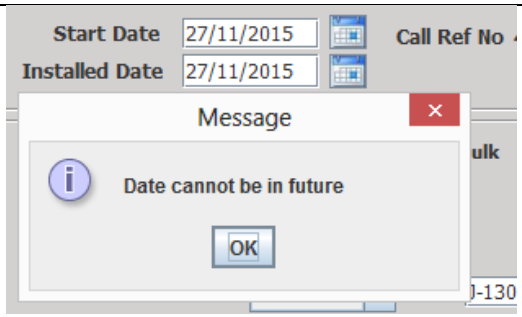
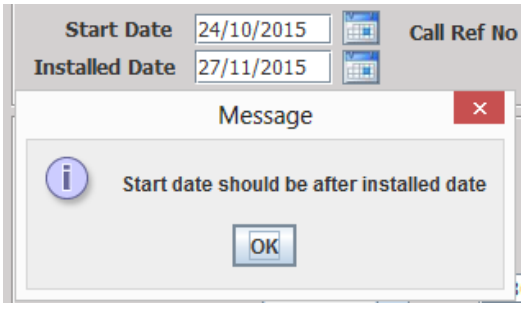
Signature **Date:**

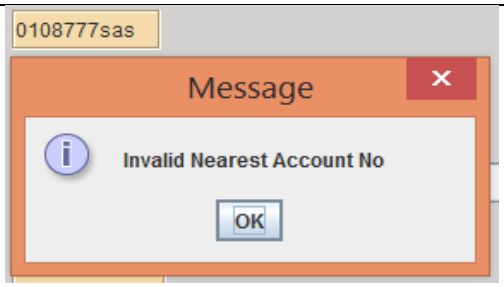
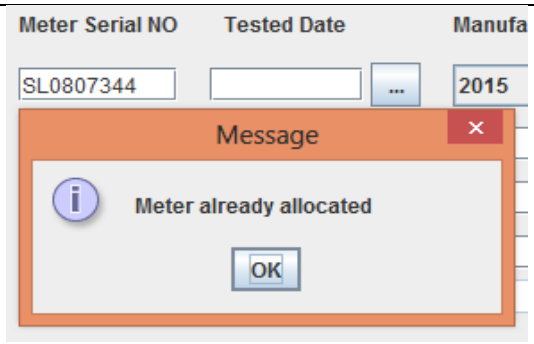
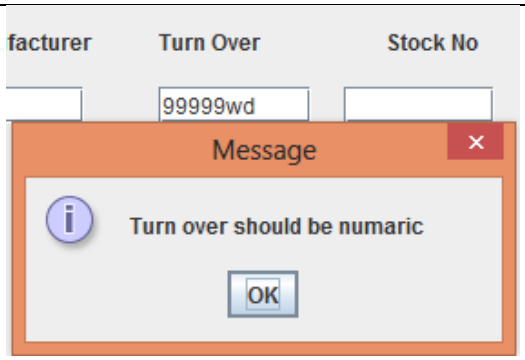
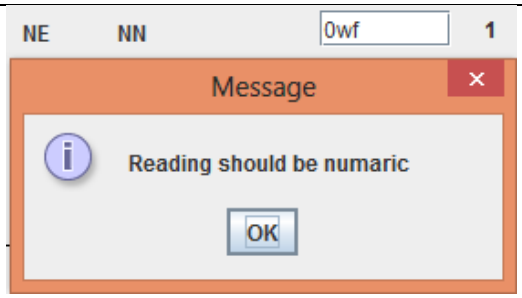
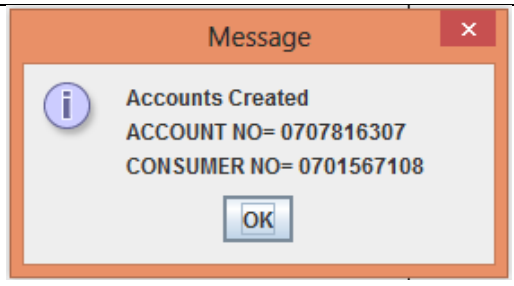
Figure 34 – Questioner

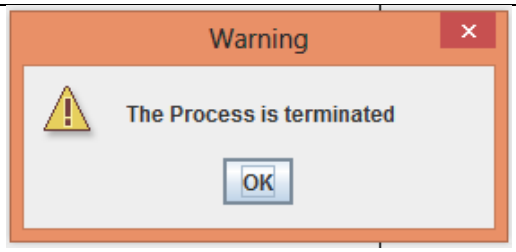
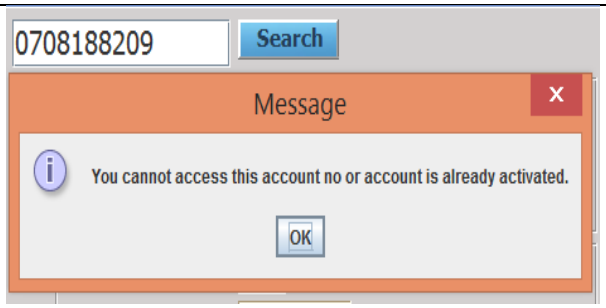
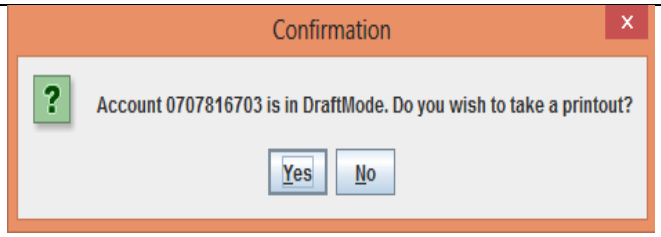
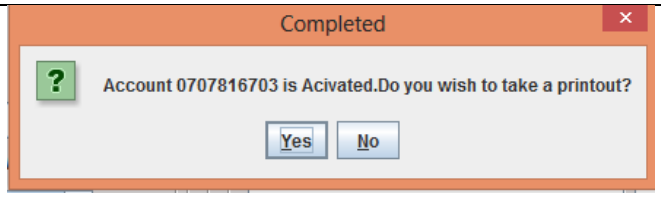
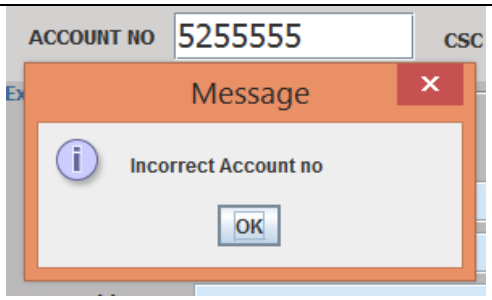
Appendix D – Test Results

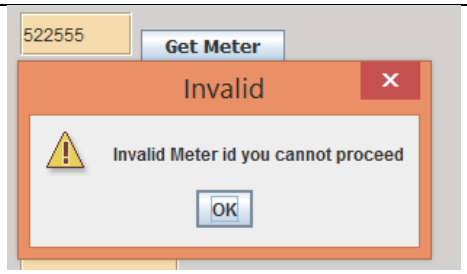
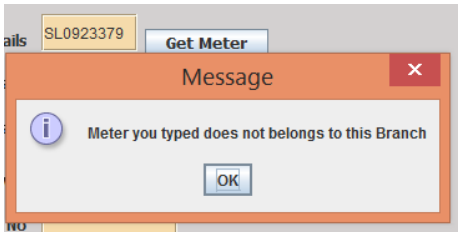
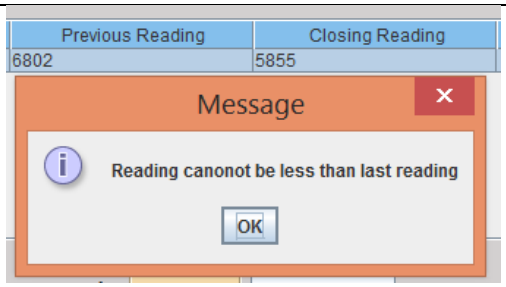
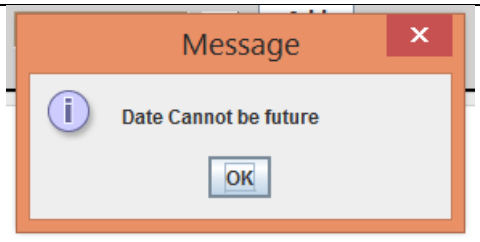
Test results are demonstrated in table 12 below.

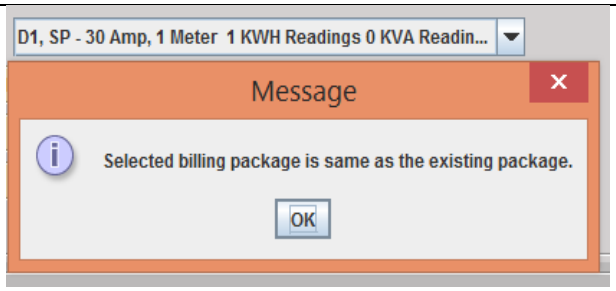
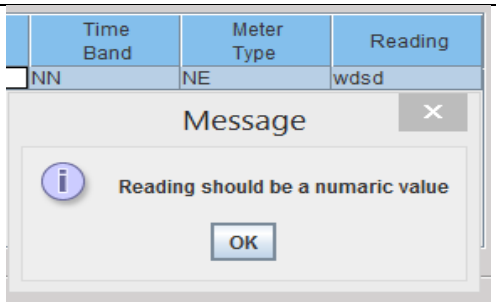
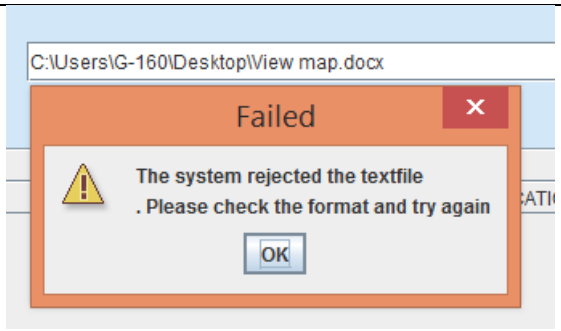
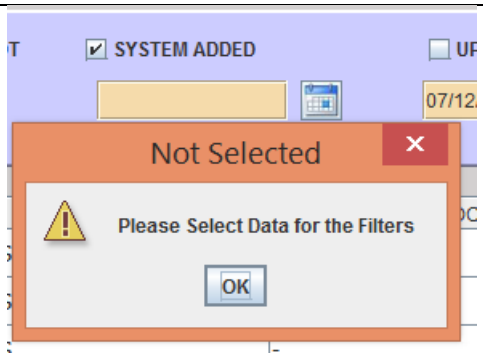
Module	Test case	Result	Status (pass/Fail)
Account Creation / Account Activation	Validate call reference number		Pass
	Validate invalid call reference number		Pass
	Validate payments with service type		Pass
	Validate nearest account no		Pass
	Validate NIC Format		Pass

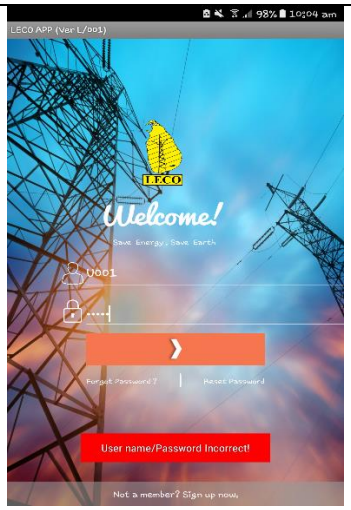
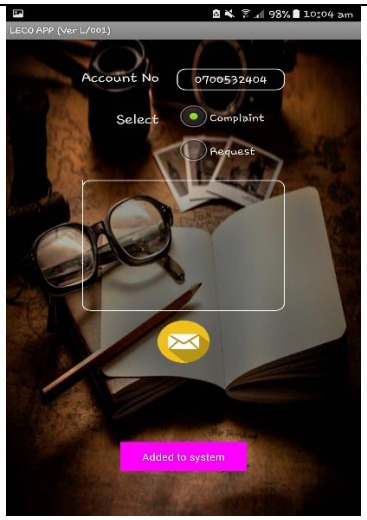
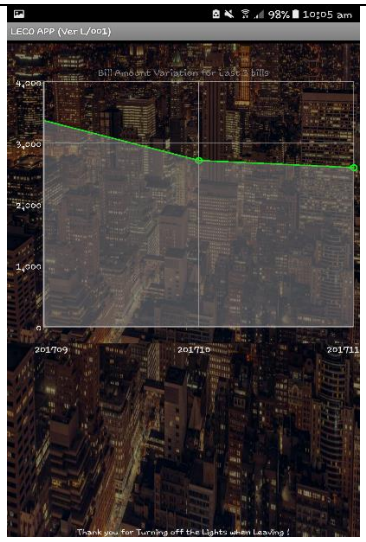
	Validate connection given date		Pass
	Validate pole number		Pass
	Validate null NIC number		Pass
	Validate consumer number generation		Pass
	Validate Installation date	 	Pass

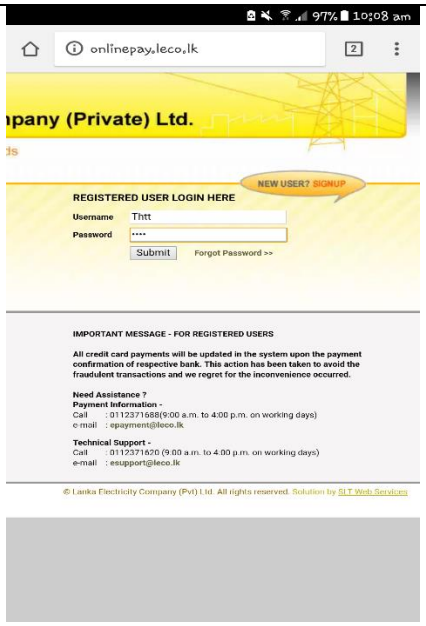
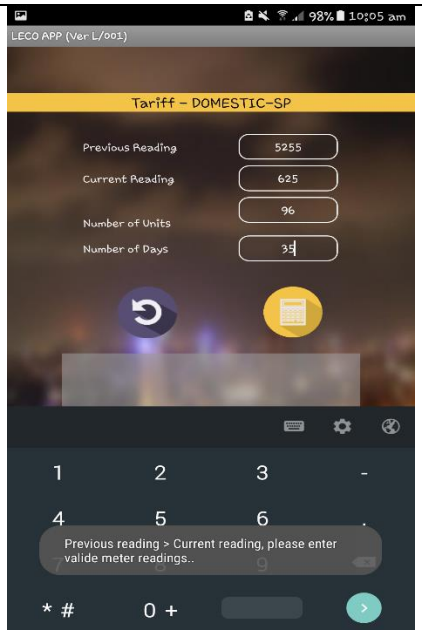
	Validate nearest account number		Pass
	Validate meter id		Pass
	Validate turn over		Pass
	Validate meter readings		Pass
	Notify user when completion of process		Pass

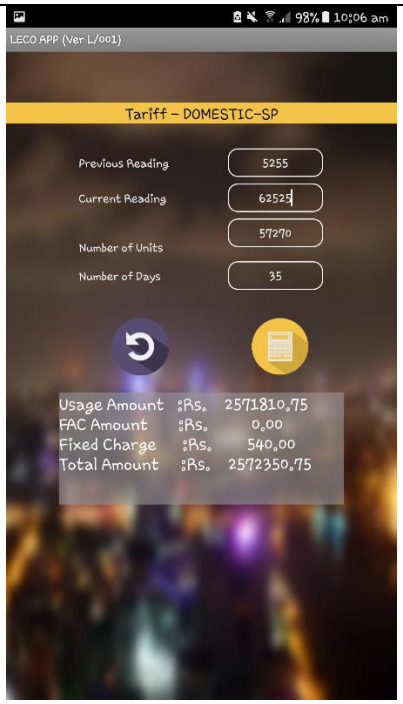
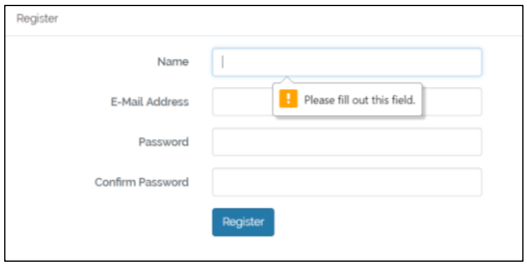
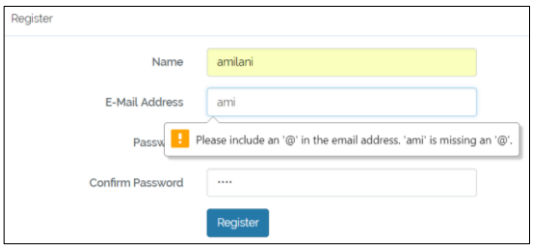
	Notify user when failure of process		Pass
	Validate account number before activation		Pass
	Notify when account in draft mode		Pass
	Notify when account is activated		Pass
Consumer Information change	Validate account number		Pass

	Allocating smart meters – validate meter availability	   	Pass
	Validate closing reading		Pass
	Validate read date		Pass

	Select same billing package as previous		Pass
	Validate new meter reading		Pass
Meter Maintenance	Validate text file		Pass
	Validate filters		Pass

Mobile Application			
Module	Test case	Result	Status (pass/Fail)
User login	Validate User		Pass
Contact us	Add complaints		Pass
Inquiry	View Graph		Pass

Payments	Authentication			Pass
Bill Calculator	Invalid reading detection			Pass

	Bill Calculation		Pass
Web Application			
Registration	Missing fields and Invalid email	 	Pass

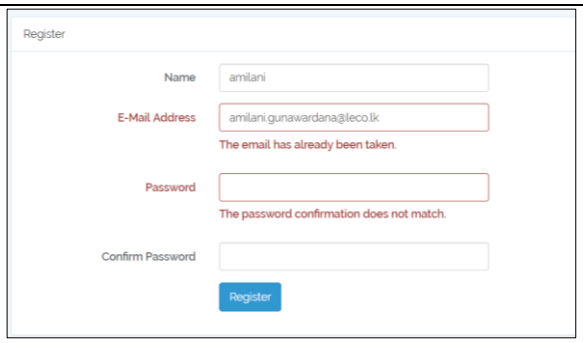
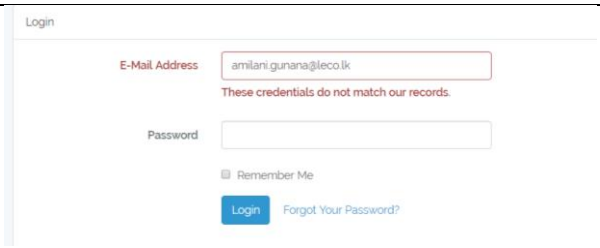
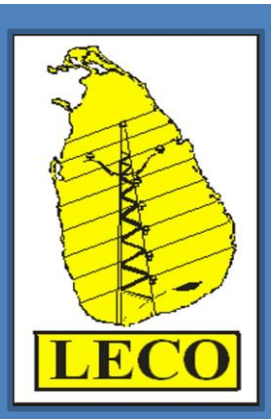
			
Authentication	Invalid user		Pass

Table 12 - Test Results

Appendix E – User Manual



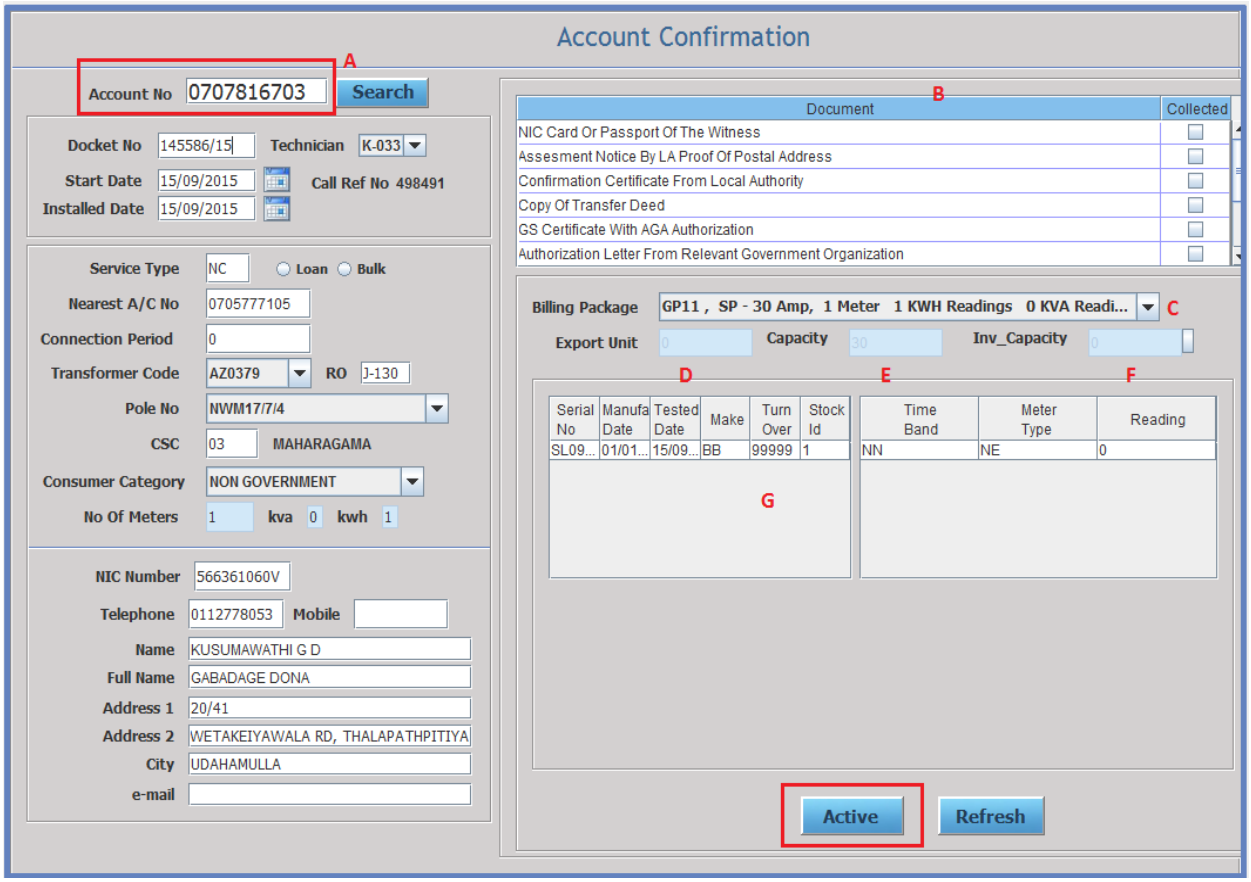
SMART METER & CUSTOMER SUPPORT SYSTEM - USER MANUAL

Version 1.7

12th January 2018

Account Activation

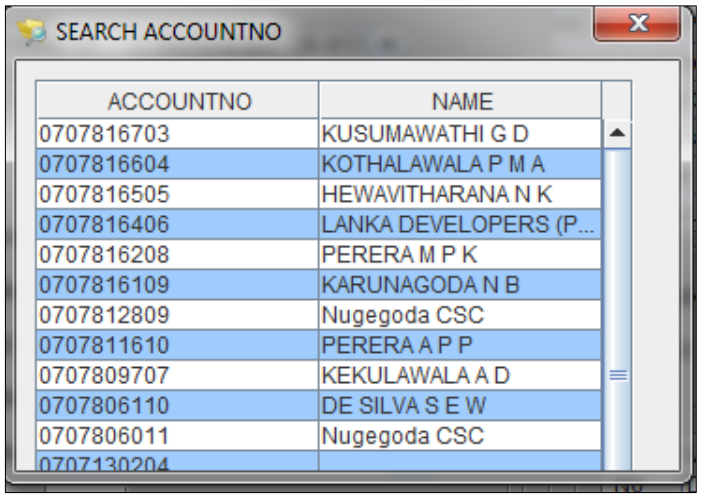
The main screen is below



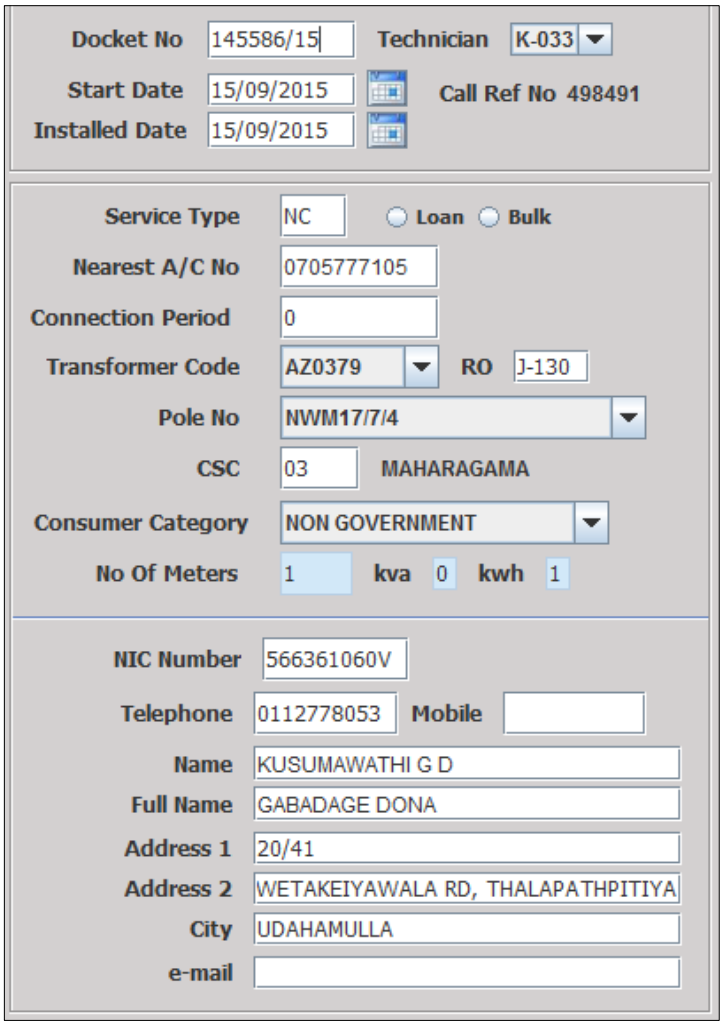
1. Edit details and put the account in to **Draft Mode**.

    - Type Account No in the **A** field and press enter
      or

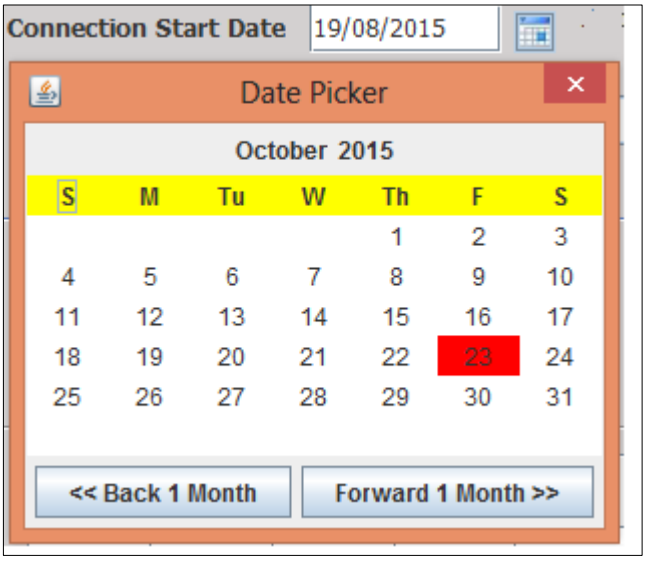
      you can use the Search button to view the available Account No.



- The following fields can be modified.

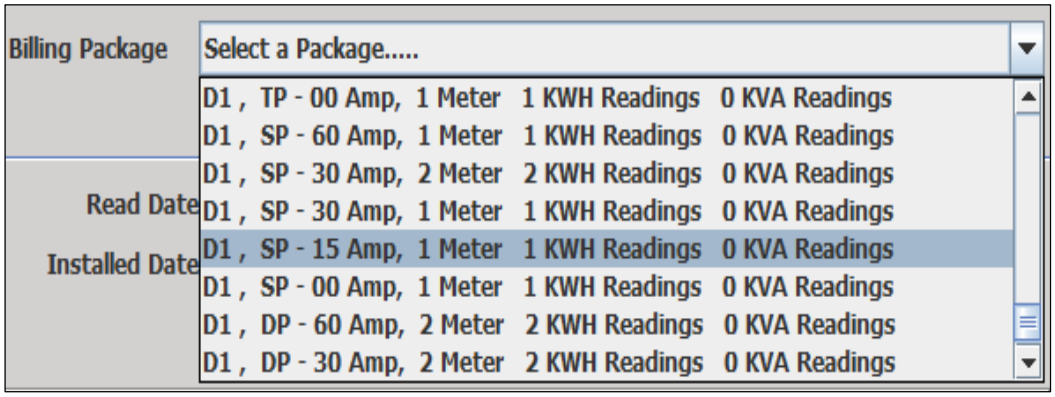


- You can use  button to change the date fields . select the date from the Figure - 5 .

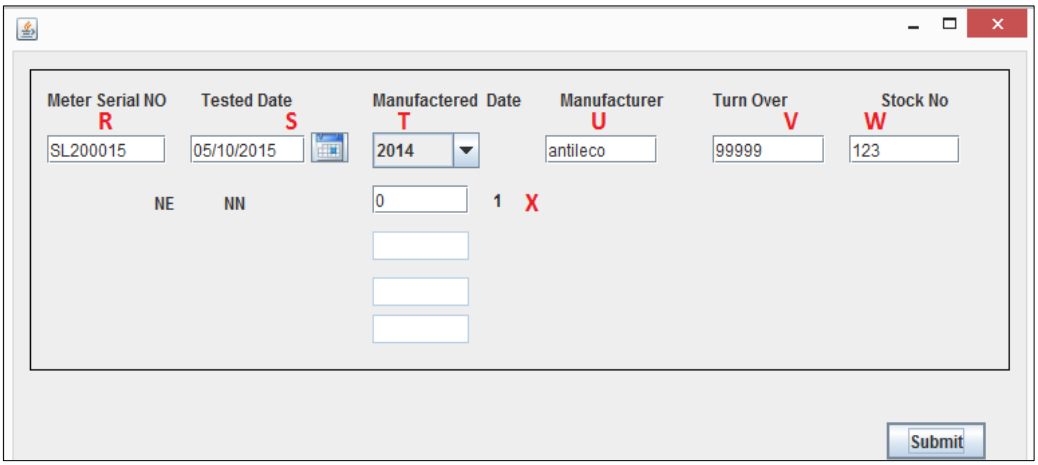


- In **B** table select the documents which were handed over by the consumer.

- Use **C** to **change** the existing billing package
  when you are changing the billing package select the new billing package and **press enter key twice (2)**



- The new window will



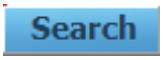
  - **R**, **S**, **T**, **U**, **V**, **W**, **X** fields are compulsory.
  - Enter readings in X fields and
  - Press **<u>enter key twice (2)</u>** to return to main page.

- If you want to edit the meter readings click on **G** table and the window in Figure-7 will appear.
  Do the changes and **<u>Press enter key twice (2).</u>**
- Note that **D**, **E, F** in Figure -2 is compulsory when the connection is **net metering**.

- Press 

to continue.
- The message will appear to inform that the account is in **<u>Draft mode</u>**. (the account is not activated yet)

2. On confirmation a report will generate and you can save the report by clicking on the  icon.

3. Activate the account
   - Type Account No in the **A** field and press enter
     or
     you can use the 

button to view the available Account No.
   - Re check the details you modified in the previous mode.
   - Note that you can modify any data in this stage.

- Once completed Press 

to activate the account.
- The message will appear when the process is complete.

4. On confirmation a report will generate and you can save the report by clicking on the  icon.

CONSUMER DETAILS CHANGE.

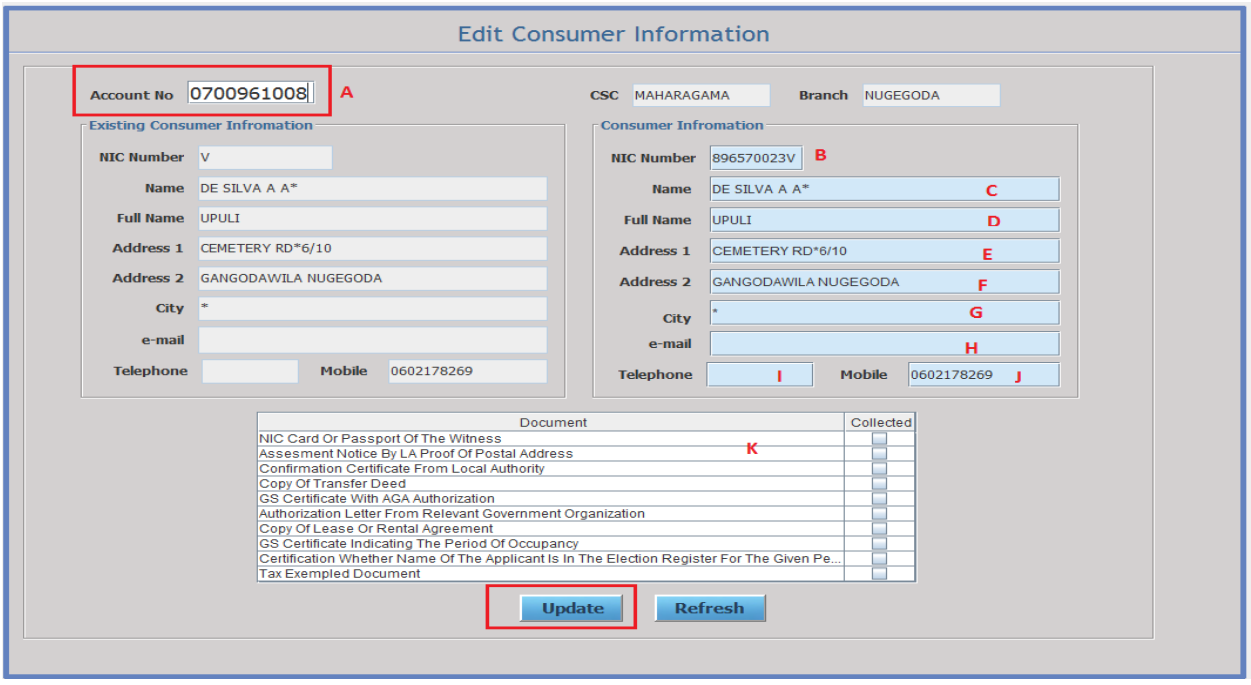
There are five main menus available under this module

1. Edit consumer name – before bills issue
2. Edit consumer information
3. Geographical data change
4. Service change
5. Consumer change

1. Edit consumer name – before bills issue

   Select Consumer Details Change➔ Name Change from main menu

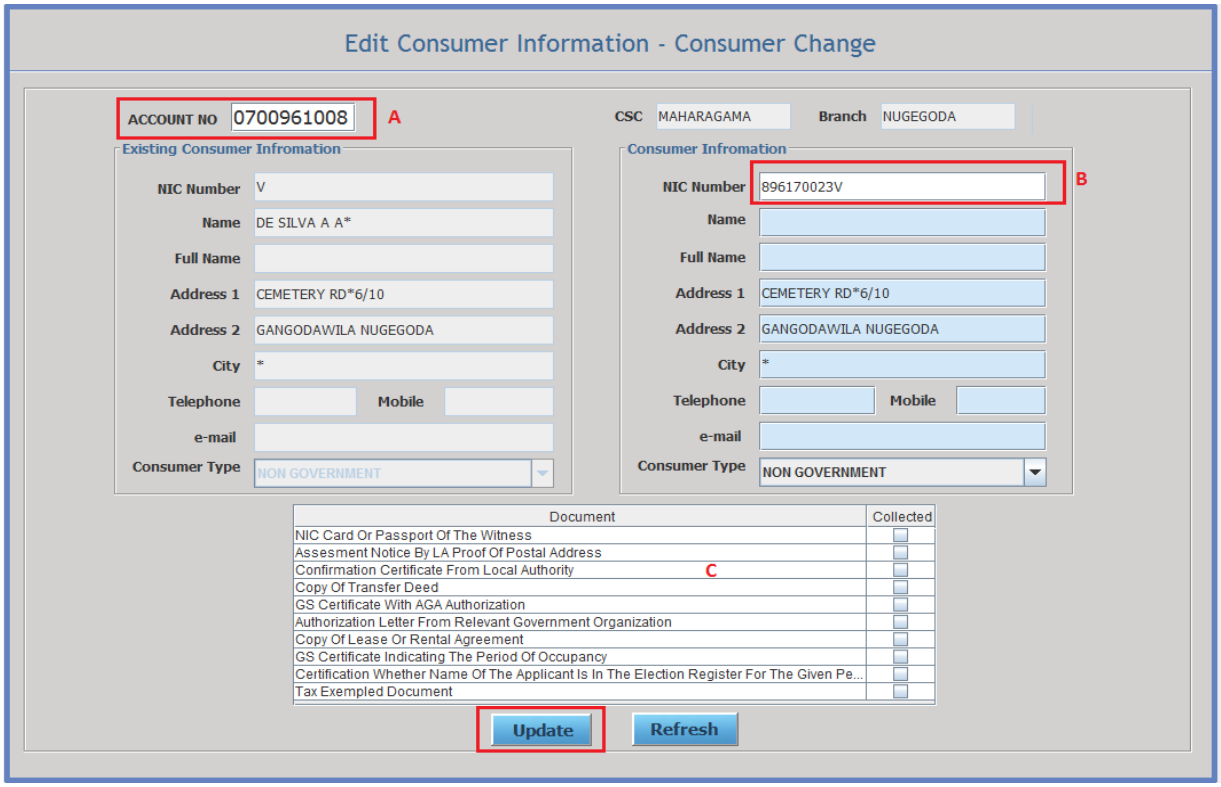
2. Edit consumer information
   Select Consumer Details Change➔ Edit consumer information from main menu



- Type account no in field **A** and press enter key.
- **B, C, D, E, F, G, H, I, J** fields are editable.
- **K** table is to input the documents consumer has submitted.
- Do the necessary changes.
- To submit details press Update and the report will be auto generated.
- Save the report by clicking on the icon.
- Use Refresh to clear the screen.

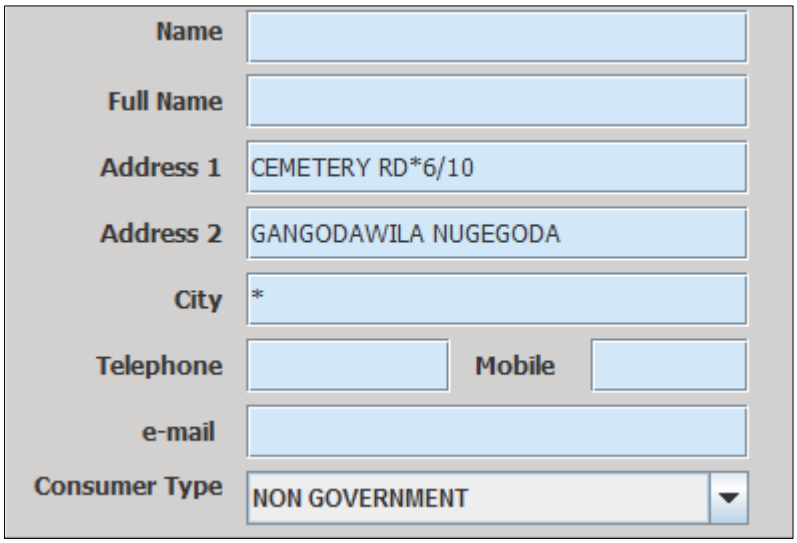
3. Consumer Change

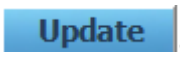
   Select Consumer Details Change➔ Consumer Change from main menu



- Type account no in field **A** and press enter key.
- Type the new consumers NIC no and press enter key.
  - If the consumer is already available under the given NIC the system will show the details

- If the consumer is not available under the given NIC enter the required fields in Figure -9.



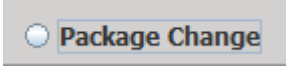
- To submit details press 

and the report will be auto generated.
- Save the report by clicking on the  icon.
- Use 

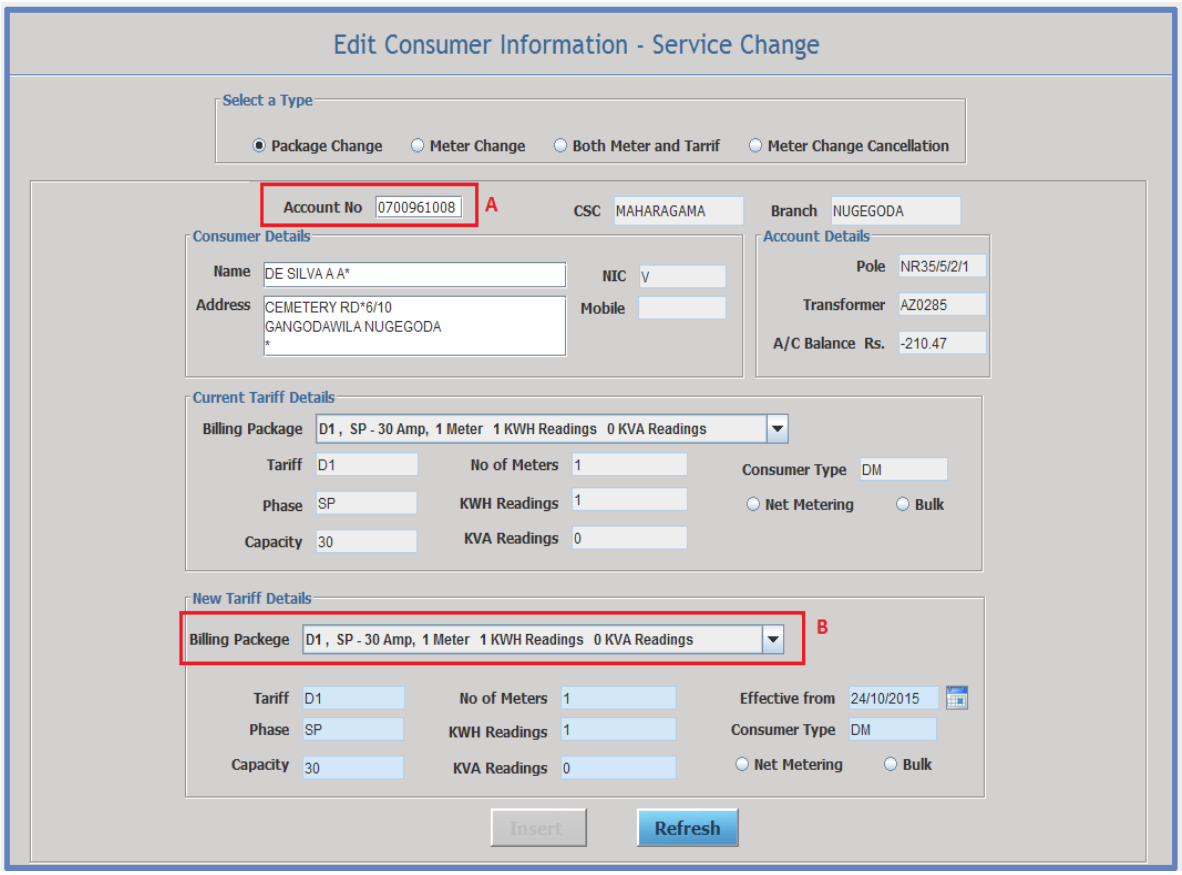
to clear the screen.

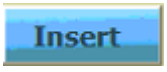
5. Service Change.
Select Consumer Details Change➔ Consumer Change from main menu
Under Service changes there are four main types available
a. Package Change – only the Service will change
b. Meter Change – only the meter will change
c. Both meter and tariff change.
d. Meter Change Cancelation.

5.a. **Package Change**

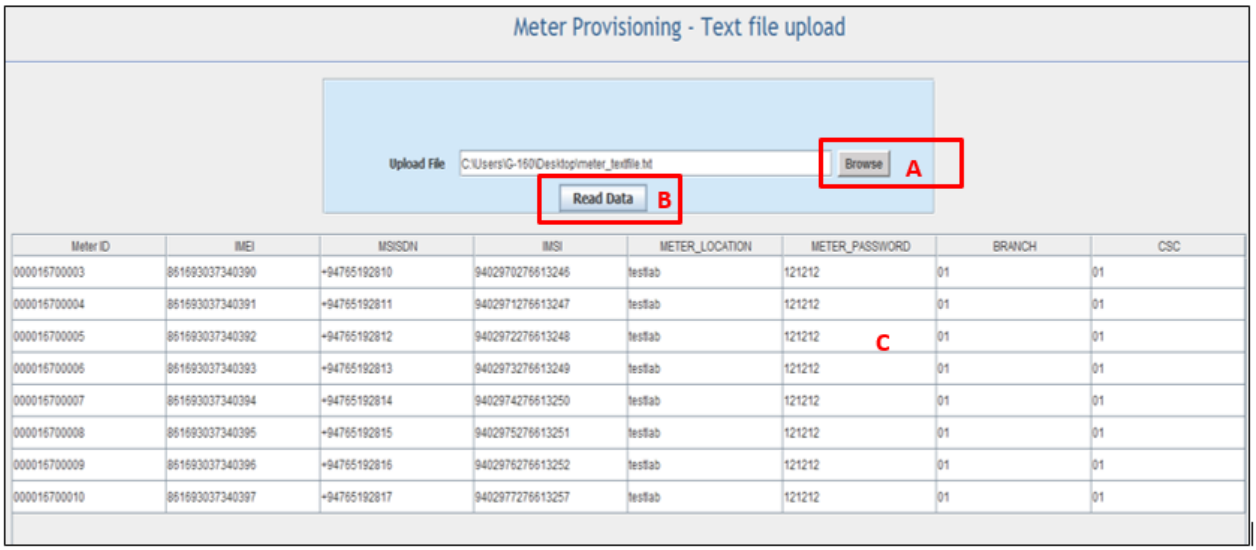
1. Click on the radio button 

.
The main window will appear



- Insert account no in field **A** and press enter key.
- Select the new billing package from field **B**
- To submit details press  and the report will be auto generated.
- Save the report by clicking on the  icon.
- Use  to clear the screen.

Meter provisioning



Meter ID	IMEI	MSISDN	IMSI	METER_LOCATION	METER_PASSWORD	BRANCH	CSC
000016700003	861693037340390	+94765192810	9402970276613246	testlab	121212	01	01
000016700004	861693037340391	+94765192811	9402971276613247	testlab	121212	01	01
000016700005	861693037340392	+94765192812	9402972276613248	testlab	121212	01	01
000016700006	861693037340393	+94765192813	9402973276613249	testlab	121212	01	01
000016700007	861693037340394	+94765192814	9402974276613250	testlab	121212	01	01
000016700008	861693037340395	+94765192815	9402975276613251	testlab	121212	01	01
000016700009	861693037340396	+94765192816	9402976276613252	testlab	121212	01	01
000016700010	861693037340397	+94765192817	9402977276613257	testlab	121212	01	01

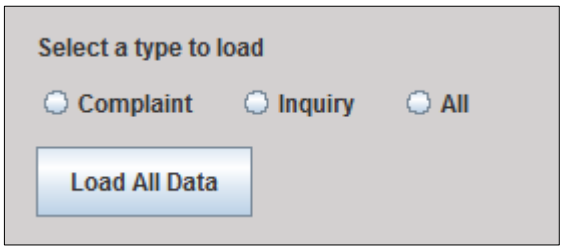
- Click **A** and select the relevant text file.
- Select "**Read Data"** field **B**
- Once data is loaded to the grid **C.**
- Click on Upload button to provision the meters.

Complaint Handling.

This interface contains 2 types of consumer requests.

1) Complaints

2) inquiries.



Select a type and Click on Load All Data button. Data will be loaded to the grid as follows.

Account No	Date	Message	Type
0700011301	2017-11-20 09:10:52.0	1212121212	C
0700532404	2018-01-04 09:27:42.0	test web comment	C
0700532404	2018-01-04 09:33:25.0	25222	C
0700532404	2018-01-04 09:49:25.0	dddd	C
0700532404	2018-02-01 08:38:21.0	WEWE	COM
0700532404	2018-02-01 08:39:11.0	REDIRECT TEST	COM

Double Click on the recore to enter feed back and data will be loaded to the form below.Enter the feedback and click on proceed button.